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Alternative reinforcement and resistance to change

Tota-Faucette, Mary Elizabeth, Ph.D.

The University of North Carolina at Greensboro, 1991

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ALTERNATIVE REINFORCEMENT AND RESISTANCE TO CHANGE

by

Mary Elizabeth Tota-Faucette

A Dissertation Submitted to
the faculty of the Graduate School at
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If alternative reinforcement is given in a context where a target behavior is occurring, the persistence, or **resistance to change**, of the target behavior increases. In previous reports, it was hypothesized that the discriminative stimulus for the target behavior acquired an excitatory effect as a result of signalling the alternative reinforcement (a Pavlovian contingency). This excitatory effect of the discriminative stimulus was assumed to be responsible for the enhanced persistence. The present research program set out to examine several other interpretive accounts of the effect of alternative reinforcement. An additional goal was to extend the generality of past findings.

Although the discriminative stimulus might exert the evocative effect responsible for enhanced persistence, it is also possible that the context (or contextual cues) can exert the evocative effects. In Experiment 1, pigeons were trained to respond to a single discriminative stimulus (S^D). This S^D was presented in two contexts, one corrrelated with a rich source of alternative reinforcement and the other with a lean source. What was found was that the contextual cue which signalled the richer reinforcement context (due to the richer source of alternative reinforcement) led to enhanced persistence (as assessed by extinction and two types of satiation procedures) of the target response.

Experiment 2 sought to replicate previous findings across species (i.e., humans) and behavior (i.e., fluid). A second purpose of this experiment was to test whether alternative reinforcement of a different type from the reinforcement given for the target would also lead to enhanced persistence. A within-subjects design was arranged where children were trained to "relax" (a fluid response). This behavior occurred in either a rich reinforcement context (due to alternative reinforcement) or a lean context. The alternative reinforcement was either of the same type as the target reinforcement or it was different. An analysis of variance revealed essentially the same effect as that found previously with pigeons. That is, the persistence of a response increased when it occurred in a situation where an alternative reinforcement source was available. This effect was found regardless of whether or not the alternative source was the same type the target source.

In sum, the present research program indicated that contextual cues that signal a target and alternative reinforcement source can evoke an excitatory effect which results in an increase in persistence. Second, the effect of enhanced persistence as a result of alternative reinforcement can be found across species, behavior, and reinforcement type.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Psychologists, both basic and applied, have long been interested in the topic of persistence. For example, from a clinician's standpoint, it would be useful to understand how to increase the persistence of positive behavior changes made in therapy (i.e., so that the new behavior is maintained in or generalized to the client's home environment). Also, understanding the variables which influence persistence may aid a therapist to eliminate unwanted persistent behavior.

Persistence, or **resistance to change**, refers to how long a behavior occurs under conditions that tend to reduce responding. Such conditions include extinction, satiation and distraction. In extinction, a previously reinforced behavior ceases to be reinforced, leading to a drop in response rate. Response rate also tends to drop in satiation, where an organism is provided with an overabundance of a reinforcing consequence. During distraction, while an organism is engaged in an ongoing behavior, a stimulus which evokes a competing response is introduced. The performance of this competing response tends to reduce the rate of the initial response.

Resistance to change, like response rate (how frequently a behavior is performed), has been thought of as a measure of a behavior's strength. For example, one might suppose that the

stronger a behavior is, the more likely one is to do it and the longer it will persist. If so, resistance and response rate should be influenced by the same variables.

A fundamental variable that influences the rate of a behavior is the contingency between the response and the reinforcer--that is, the operant contingency. One might suppose that this contingency would also influence persistence.

The Operant Contingency

Consequences change the probability of occurrence of the behavior that produced them (e.g., Skinner, 1953). A behavior is "strong" in the sense that it becomes more probable or frequent in the future. When the correlation between a response and its consequence is high, the result is a highly probable behavior. Thus, to make a behavior stronger, one should arrange a tight operant contingency, where the behavior is consistently followed by reinforcement and the reinforcement is presented only when the behavior has occurred.

It is well-known that tightening the operant contingency--for example, by increasing the frequency of reinforcement for a response--will increase that response's rate. If persistence were similarly affected by the operant contingency, then as the frequency of reinforcement increases, a behavior's persistence ought to increase as well. Thus, continuous reinforcement (CRF) should produce a strong (persistent) response, while intermittent reinforcement should

produce a weaker (less persistent) response.

For example, if satiation were used to decrease the rate of a response, one would expect that the more frequently a behavior has been reinforced during baseline training, the more resistant to satiation it becomes. Indeed this has been found. When extinction was used to assess persistence, however, the response that had been reinforced intermittently was reported to be more persistent than a response that had been continuously reinforced (CRF) (see Mackintosh, 1974, for a review). This finding (dubbed the parital reinforcement effect) was contrary to what was found with the satiation procedure. It was also contrary to the idea that increasing the reinforcement for a response leads to a stronger response, in terms of persistence. Nevin (1988), however, Nevin re-examined the methods and data that seemed to show the partial reinforcement effect. He argued that this effect may partly have been the result of an artifact of the extinction procedure.

First, Nevin observed, the extinction procedure confounds the decremental effects of the stimulus change with the effects of non-reinforcement. That is, the change in stimulus conditions from CRF to extinction is greater than that from intermittent reinforcement to extinction. Thus, the subject may be able to detect the change from CRF to extinction more quickly than from intermittent reinforcement to extinction. Such a difference, and not the schedules themselves, may have been a factor in the partial reinforcement effect.

Second, Nevin noted that in these early studies the slopes of the

resistance test functions, **relative to baseline**, were not examined. That is, the initial level of responding was ignored. To illustrate the point, suppose there are two responses. Response A has an initial response rate of 60/min resulting from a CRF schedule, while B, on an intermittent schedule, has a response rate of 30/min. During extinction, A drops to 30/min in 5 minutes, a 50% decrement. B drops to 10/min in the same amount of time, a 67% decrement. The absolute drop in response rate after five minutes in extinction is greater for A (a drop of 30 responses per minute) than B (a drop of 20 responses per minute). Yet, when the decrement in responding is compared with the initial level of responding (or baseline), it is clear that proportionally, the drop in A's rate is smaller than that in B (50% versus 67%). The slope of this function plotted on a log scale (which reveals relative differences) from the initial level of responding to level of responding in extinction, reveals that Response B's slope is steeper than A's. Thus, controlling for initial level of responding would lead one to argue that A (the response on the CRF schedule) is more resistant than B (the response on the intermittent schedule).

Thus, the partial reinforcement effect was found only under a special set of conditions and when these conditions are controlled for (e.g., controlling for stimulus-change effects, examining the slopes of the extinction functions relative to baseline rates), the general finding is that the higher the rate of reinforcement during baseline, the greater the persistence of responding during extinction (Nevin,

1988). Thus, if rate and persistence are influenced by different variables, the studies reporting the partial reinforcement effect did not succeed in showing this.

In sum, manipulating (i.e., tightening or strengthening) the operant contingency by increasing the frequency of reinforcement available for a response increases both the **rate** and **persistence** of a response.

Alternative Reinforcement

As described above, one way to manipulate the operant contingency is to increase or decrease the frequency of reinforcement for a response. A second way is to deliver additional reinforcement either freely or contingent upon a second response in the situation where the target behavior is occurring. Alternative reinforcement weakens the correlation between the target response and the reinforcer, since the reinforcer is sometimes delivered when the response has not occurred.

It would be expected, then, that alternative reinforcement would cause the rate of the target response to decrease, similar to when the operant contingency is weakened by intermittent reinforcement. Indeed, such changes occur (Reynolds, 1961) and are well described by Herrnstein's equation (1970):

$$B = k \frac{R}{R + R_o}$$

where B represents the rate of responding, R represents the rate of reinforcement, R_0 represents the rate of "other" reinforcers in the environment not given explicitly for B, and k as a constant. This equation predicts that as R_0 increases, while R remains constant, B (response rate) decreases.

The discovery that alternative reinforcement affects the rate of a target response was important because it highlighted the fact that one should consider the events surrounding the contingencies for the target when controlling or predicting behavior. An example of such a consideration was provided by McDowell (1982). He reduced the rate of an unwanted problem behavior in a child (scratching) by providing alternative reinforcement for other behavior in the situation. The rate of scratching then decreased.

Herrnstein's equation has wide generality, both when R_0 is from a concurrent source or from a component of a multiple schedule (Herrnstein, 1970; Williams, 1983). The effect described by this equation is also generally familiar. For example, parents know that if a child is given an allowance for doing chores, such as making his bed, he will probably do his chores at a satisfactory rate. If the parents start giving the child additional money for "free" (non-contingent on any behavior), one would not be surprised to see the rate of "bed-making" decrease.

In sum, two means of altering the operant contingency (i.e., decreasing the reinforcement given for the target and giving

alternative reinforcement) decrease response rate as predicted by the degree of the correlation between response and reinforcer.

Resistance to change, like response rate, has also been found to co-vary with the correlation between response and reinforcer when the contingency is manipulated by increasing or decreasing the reinforcement of a target response. But what is the effect of alternative reinforcement on persistence?

Recently, several researchers examined this effect. Two such experiments are reported by Nevin, Tota, Torquato, and Shull (1990). With pigeons as subjects, Experiment 1 of Nevin et al. examined the effect on persistence of adding noncontingent reinforcement (free food delivery) into a situation where the target response, keypecking, was occurring. In Experiment 2, the additional reinforcement was produced by a second response (i.e., contingent upon pecking a second key) and was not delivered freely. In this experiment, two situations were compared with one another. In both situations, a right and left key of the same color, were presented concurrently. The two situations were denoted by different key colors (e.g., either both keys were red or they were both white), and their presentations alternated over time. In both situations, the target response was right-key pecking, which was reinforced at a rate of 15 food presentations per hour. In Situation A, an additional 45 reinforcers per hour was available for left-key pecking. These additional 45 reinforcers per hour served to degrade the contingency between the target response and reinforcement. In Situation B, in

contrast, no reinforcement was available for responding to the left key; thus, no additional source of reinforcement was available.

In both Experiments 1 and 2 of Nevin et al., an additional source of reinforcement led to a **decrease** in the rate of a target response during baseline, as expected. These findings replicated past results and are predicted by Herrnstein's equation. The effect of additional reinforcers on resistance to change, however, was just the opposite. Alternative reinforcement during training led to an **increase** of the target response's persistence. Thus, while added reinforcers caused the target behavior to drop in frequency, it caused the behavior to persist longer during extinction and under two types of satiation. This effect was found regardless of whether the additional reinforcement was given freely or contingent upon a second response.

Based on our usual views of operant conditioning, the effect of alternative reinforcement on persistence is counter-intuitive. Degrading the operant contingency should weaken behavior. Adding alternative reinforcement does reduce response rate, but it increases persistence. If this effect is general, it behooves us to think differently about the variables that influence operant behavior.

For example, it may no longer be useful to think of rate and persistence as correlated aspects of behavior, determined by the same variables. Instead, it appears that rate is determined by the response-reinforcer contingency, and persistence may be more determined by the situation (stimulus)-reinforcer contingency. That

is, persistence appears to be not only dependent upon the reinforcement given for that response (as response rate is) but also to be somehow influenced by the total rate of reinforcement delivered freely or for other responses in the situation, (that is, the overall rate of reinforcement in the situation) (Nevin, Smith, & Roberts, 1987). Yet, how does this overall rate of reinforcement result in enhanced persistence?

The Pavlovian Contingency

In some earlier reports, Nevin (e.g., 1984) argued that enhanced persistence is a result of a Pavlovian contingency between the TS^D and the rate of reinforcement it signalled. Specifically, the TS^D is thought to gain excitatory strength as a result of this Pavlovian conditioning. The TS^D is, in other words, a conditioned stimulus (CS) (See Figure 1. Note: All figures may be found in Appendix A). Yet the effect which is evoked (which leads to an enhancement of persistence) is not a specific conditioned response, but rather a non-specific excitatory effect, akin to a general arousal or motivational state.

Others have written about arousing or motivational effects, and only recently has there been renewed interest in such variables within behavior theory. For example, Skinner (1953) wrote about "emotional pre-dispositions" which lead to a general heightening or depression of activity. Killeen (1979) defined "incentives" as "events that generate a heightened state of arousal and thereby increase the

vigor (amplitude and rate) of ongoing behavior". Those interested in context conditioning and operant/Pavlovian interactions have also written about the facilatory functions that stimuli may serve (Holland, 1983) or about the generalized motivational states that may be evoked by stimuli (Rescorla & Soloman, 1967). It may be that the effects talked about by Skinner ("emotional predispostions") or Killeen ("incentives") are similar to the effect described by Nevin (1984).

Although Nevin (1984) argued that the TS^D was the stimulus which became evocative, and thus was responsible for enhanced persistence, it is also possible that it is the context which becomes evocative. That is, contextual cues may also be seen as signalling a given rate of reinforcement. It seems possible that through this signalling of reinforcement, such cues may also become evocative. Given that contextual cues may potentially affect a wide range of behavior, it would be important to determine if the context can influence the persistence of operant behavior.

Contextual Cues

In this report, the term "contextual cue" will often be used; thus, it seems prudent that this term be defined. Before presenting the definition, an example may provide a useful aid. Imagine a center key in an experimental chamber that can be lit green or red. The rate of reinforcement during green is higher than that during red. The key color (green or red) is a distinct feature. The pigeon

responds differently to the two keys, with response rate being higher to the key-color associated with the higher rate of reinforcement (green). There are also features common to these two sources of reinforcement (green and red), such as cues which define the experimental chamber (floor, etc.) or key-shape (see Nevin, 1991, for a related discussion).

To give a more everyday example, suppose a child is confronted with a math problem in class. He receives a given rate of reinforcment for doing his math problems. This child also receives stars for good behavior in this class (a second source of reinforcement). The common feature across both sources of reinforcement are those which define "math class" (e.g., the math book, the math teacher). The common features in both of these examples appear to define a context, and thus may be called contextual cues.

What effect on behavior do these common features have? One effect of common features is that generalization occurs. For example, if a pigeon's responses to a circle are reinforced, then he may also respond to an elipse, as a result of the circle and elipse having the feature "roundness" common to both. In the key light example above, the rate of responding to the red key may increase as a result of reinforcing responses to the green key, as a function of these two keys having the feature of key shape (for example) common to both. Thus, response rate increases to a given stimulus as a function of

reinforcing responses to a second stimulus, when the two have features common to both.

Empirical evidence, however, suggests another effect of common features on rate. When a target and alternative source of reinforcement have features common to both, the result of increasing alternative reinforcement is a decrease, not an increase, in responding to the target stimulus. This effect has been described by Herrnstein's equation (discussed earlier) and has been termed behavioral contrast (Reynolds, 1961). How might common features contribute to such an alteration in rate?

Suppose another function of shared features is to provide a reference to which a rate of reinforcement in the presence of a stimulus can be compared. For example, suppose a green key signals 60 reinforcers per hour while a red key signals 30 reinforcers per hour. The common features between green and red (the chamber cues) signal the average rate of reinforcement between green and red ((60 + 30) / 2 = 45). The rate of reinforcement signalled by each target discriminative stimulus is compared to this overall average. How evocative the key color becomes depends on its comparison to the overall context (or the average rate of reinforcement signalled by the common features). Relative to this average, the green (which signals the higher rate of reinforcement) will compare better to this average (60 vs 45) than the red (30 vs 45), thereby resulting in a greater evocative effect for green. Thus, responding to the green stimulus may increase, while responding to the red decreases.

The evocative strength of the green and red stimuli may also affect the persistence of a response. As a result of how evocative a stimulus becomes, persistence may be enhanced or depressed. Thus, the responding to the green key may persist longer than responding to the red key.

Thus, for the present purposes, a contextual cue will be defined as the features common to reinforcement sources. The effect of common features is to provide a reference for stimuli, which results in a stimulus becoming more or less evocative. The evocative strength of a stimulus then affects: (a) the rate of responding; and (b) the persistence of the response. In sum, what is being described here is a relativistic conception of conditioning. Such a conception is not a new one (see for example a discussion of the C/T ratio, Gibbon & Balsam, 1981).

In the example given above, the greater evocative effect gained by the green stimulus should result in similar effects on both rate and persistence, that is, they should both increase. In Nevin (1984) and other reports (e.g., Nevin et al., 1990), however, the evocative effect of a target stimulus led to different effects on rate and persistence. That is, the rate of the target response <u>decreased</u>, while the persistence of the target <u>increased.</u> Can these effects be adequately accounted for by the relativistic conception of conditioning described above?

In Nevin (1984), two target keys were arranged in an experimental chamber, one on the right side and one on the left side.

The rate of reinforcement given for each TS^D was the same. Each TS^D was followed by the occurrence of an alternative reinforcement source, which was presented on the same key but denoted by a different key color. The TS^D on the left side of the chamber was red and was followed by a key color switch to white, where a rich alternative reinforcement source was available. The TS^D on the right side was green and was followed by orange, during which a lean reinforcement source was available. While each TS^D and alternative source key pair were composed of distinct features (key color), there were also features common to both, which was key position (left or right). Thus, the contextual cue for the red-white pair was left key position, while for the green-orange pair it was right key position. Each contextual cue signalled a given rate of reinforcement (i.e., the left key position signalled a higher average rate of reinforcement than the right key position). Thus, the rate of reinforcement available during red is relatively poor compared to the rate signalled by the left key position (due to the alternative reinforcement). According to the the relativistic conception of conditioning, the TS^D associated with the alternative reinforcement becomes less evocative, thus there should be a drop in both rate and persistence.

It should be noted that in Nevin (1984) and other studies examining alternative reinforcement and resistance to change (e.g., Nevin et al., 1990), two nested contexts were arranged. Nested contexts are common both in and outside of the laboratory. The contextual cues which define nested contexts may increase in

number and abstractness. For example, in the case of the child working a math problem, there are features common to both math class and English class, which are those that define the context "school" (e.g., blackboards, teachers, uniforms).

In Nevin (1984), in addition to the features common to the two reinforcement sources (target and alternative), there were also features common to the two contextual cues (right and left key position)--namely, features of the experimental chamber. So while each contextual cue signalled a given rate of reinforcement (the left key position signalled a rich rate of reinforcement while the right key position signalled a leaner rate of reinforcement), the experimental chamber cue signalled the average rate of reinforcement on all four keys. Thus, the rate signalled by the contextual cue may be compared to the average rate of reinforcement (available in both contexts) signalled by the chamber cues. Relative to the overall average rate of reinforcement signalled by the experimental chamber, the rate of reinforcement in the richer context (signalled by the left key position) compares better than the rate of reinforcement in the leaner context (signalled by the right key position). Thus, the left key position as a contextual cue attains greater evocative strength than the right key position. This key may then evoke an excitatory effect, as a generalized arousal state, which results in enhanced persistence.

Based on this analysis, it may be that the TS^D actually is less evocative in the situation with alternative reinforcement. This

results in the observed drop (the contrast effect) in rate of the target response when alternative reinforcement is present. Yet, it may be the contextual cue which signals the rich context (due to alternative reinforcement) which becomes evocative. The excitatory effect evoked by the cue appears to affect persistence only (not rate) and its effect is opposite to the effect evoked by the TS^D.

Experiment One

It appears that the relativistic conception of conditioning can account for all aspects of the data in the previous research, namely, the drop in rate but increase in persistence. The hypothesis that it is the TS^D, functioning as a CS, which evokes the facilitating effect accounts for enhanced persistence but does not appear to explain the observed drop in rate. In the Nevin (1984) study and others (e.g., Nevin et al., 1990), it could not be empirically determined if enhanced persistence was the result of an excitatory effect evoked by the contextual cue or the TS^D. In these past procedures, there was the opportunity for either type of conditioning to occur (see Figure 2). Thus, it has not been clearly demonstrated that a contextual cue could evoke an excitatory effect which results in enhanced persistence. In order to examine this, it is necessary to arrange a procedure where conditioning can occur to the contextual cues only and not to the TS^D. One way to do this is to present the same TS^D in the presence of two different contextual cues, with one contextual cue signalling a higher rate of reinforcement (as a result of

alternative reinforcement), than the other. This will ensure that if differential resistance is found between the target dependent upon the context in which it takes place, it will be due to the excitatory strength of the contextual cues (as these differ) and not the TS^D (as this remains the same).

The main purpose of the two phases of Experiement 1 was to arrange a paradigm where the TS^D would be unlikely to become evocative, while the contextual cue could. The persistence of the same target response was assessed in two different contexts, one rich in alternative reinforcement and one lean in alternative reinforcement.

Experiment 1 accomplished this by arranging a paradigm similar to that used by Nevin (1984). The present experiment differed by using a conditional discrimination paradigm. A trial consisted of a center key being lit green first, followed shortly in time by the key being lit red. Key color was the S^D for keypecking. Contextual cues were provided by side lights in the chamber. That is, either a left or right side light was on throughout each green-red trial.

The first phase of Experiment 1 was most similar to Nevin (1984), where the alternative reinforcement source followed the presentation of a target-response stimulus, as in a forward Pavlovian conditioning paradigm. In this phase, the "forward" Phase, the target response was GREEN keypecking. Regardless of which side light was on, responding during green was reinforced at the same rate. The

alternative source of reinforcement was available, in this phase, for responding during red. The rate of reinforcement on the red key differed depending upon the contextual cue. When the right light was on, responding during red resulted in a rich rate of reinforcement, while when the left light was on, responding during red resulted in a lean rate of reinforcement.

It was hoped that the side lights, or contextual cues, would provide a reference so that the rates of reinforcement during the green and red keys would function relative to the contextual cue. Yet, because the target and alternative sources were separated in time, there was some reason to wonder if such contextual control would occur. If the side lights did come to function contextually, then effects on the rate of the target behavior, as a result of the alternative source, should be seen. That is, as is implied from the conception of relativistic conditioning (as well as Herrnstein's equation) the relative differences in the rates of reinforcement between green and red should result in differences in green-key responding depending upon the schedule in red. For example, when the rate of reinforcement in red is rich, responding during green should decrease, evidencing behavioral contrast (Reynolds, 1961). However, when the schedule in red is lean, then responding to green should increase. Even though the rate of reinforcement in green does not change, its relation to the context does.

It still may be difficult to determine in this procedure whether enhanced persistence, if found, is due to the contextual cue. That is,

it is possible that the green key plus the side light may come to function as a compound S^D (i.e., like a TS^D) for the target. It is possible that this compound TS^D may become excitatory by functioning as a CS--that is, the compound may signal the alternative reinforcement.

One purpose for conducting the forward arrangement is to observe whether enhanced persistence can be replicated in this procedure. The conditional discrimination arranged here is a difficult one and it would not be surprising if it were too difficult for the subjects to make. Since enhanced persistence was found in this paradigm, a second phase was conducted which more explicitly tested whether contextual cues can be facilitory.

This second phase, or the "backward" phase, attempted to prevent conditioning to the TS^D while still providing more additional reinforcement in one context over the other so that one context could become more excitatory.

In this "backward" phase, a backward pairing paradigm was arranged where additional reinforcement was presented before the TS^D. Thus, the TS^D did not signal the alternative reinforcement. In this phase, the target response was RED key pecking, while alternative reinforcment was available for responding to green. Recall that green is always presented before red. The side lights signaled when the schedule in green was rich or lean (See Figure 3 for a diagram of both phases).

Because the TS^D (red) does not signal the alternative reinforcement in the backward paradigm (because the additional reinforcers are presented before the TS^D is presented), the TS^D is not likely to gain in evocative strength. Such backward pairing normally does not result in excitatory conditioning to the stimulus which precedes it (Reynolds, 1945). Even if the red key and the side light came to function as a compound S^D, this backward procedure should minimize any additional excitatory conditioning to this compound, again because the compound still would not signal the additional reinforcement.

The backward procedure, though, permits the contextual cues to become excitatory, as in the forward phase, because these cues still signal the average rate of reinforcement in both the the target and alternative sources. As in the forward phase, if contextual control occurs, then response rate in the presence of the red target stimulus should differ during baseline depending upon the context. Response rate during red should be lower in the rich reinforcement context than in the lean reinforcement context.

If enhanced persistence is found in the forward phase but not in the backward phase, then we may conclude that the facilitation evoked by contextual cues is minimal to none. Instead, enhanced persistence is likely to be the result of facilitation by the specific TS^D.

If contextual cues can serve a facilitating function, then in both phases during baseline, the target response rates should differ depending upon the context. That is, target response rates should be

lower in the rich context than in the lean context. During extinction and satiation, however, the target response should persist longer in the rich context than in the lean context.

It should be noted that there are interpretations other than the one based on Pavlovian processes described above for the resistance data. One of these is based upon Herrnstein's equation which emphasizes relative rates of reinforcement as determiners of response strength. This account, however, may not be fundamentally different from the Pavolvian one, as the equation may formally describe the Pavlovian relations (see Appendix B).

In addition, there are some other accounts of the resistance data which point to the effect as being the result of local rates of reinforcement, "misattribution" or superstition. The paradigm in Experiment 1 will also be able to evaluate such accounts of the data (see Appendix C).

CHAPTER II

METHOD OF EXPERIMENT ONE

Subjects

The subjects were seven white Carneaux pigeons. They were maintained at about 80% of their free-feeding weights. Birds obtained grain during experimental sessions but were also given supplementary feedings following the sessions as needed. Water and grit were continuously available in each bird's home cage. Four of the six birds participated in both phases of the experiment. Two birds participated in Phase-forward only, and one bird participated in Phase-backward only.

Apparatus

The experiment was conducted in a standard three-key pigeon chamber measuring 36 cm across the front panel, 36 cm from front to back and 36 cm in height. On the front panel were three keylights, a houselight, and an opening giving access to a food hopper. The response keys were positioned behind circular openings 2 cm in diameter. They were 8 cm apart from center to center and 27 cm above the chamber floor. The center key could be illuminated green or red while the left and right keys were only illuminated white. The opening of the hopper measured 6.5 cm wide, by 5 cm high, and was centered on the front panel. Its bottom was 11.5 cm

from the chamber floor. A blower provided ventilation and masking noise. The variable-interval (VI) schedules were randomly produced by a dedicated computer (Walter & Palya, 1984) situated in another room. The computer also controlled the conditions and collected data.

Procedure

Preliminary training. The birds were autoshaped in the chambers. After keypecking apppeared, they were placed on the experimental conditions, but with responses in all components reinforced under equal VI schedules. After pecking was maintained over two days, the birds were placed on the baseline schedules for the experiment (unless responding dropped out at which point the VI on which they were placed was increased slowly to approximate the baseline schedules over days).

Baseline training. A center key in the experimental chamber was illuminated green or red. All trials consisted of this key being illuminated green for one minute, followed by a minute of red illumination. Two contexts were arranged and signaled by whether a right or left light was on. Thus, these side lights defined which context the subject was in. In the "forward" phase, responding during green (the target), irrespective of which of the side lights was on, produced food under a VI 60-s schedule. After the minute had elapsed, there was a 5-s timeout, when the chamber was darkened, after which the center key was lit red, which resulted in alternative

reinforcement when pecked. If the left light was on (denoting the lean reinforcement context), pecking the red key produced food under a VI 240-s schedule. If the right light was on (rich reinforcement context), pecking the red key produced food under a VI 15-s schedule. The red key in both contexts remained on for one minute. After one minute in the red had elapsed, there was a one minute timeout when the chamber was darkened. This longer timeout was imposed to make the two contexts distinct by separating them in time. After the timeout, a new context was presented, with the order of the presentation of the rich and lean contexts being random. Each bird was given thirty trials per day and run seven days a week. Thus, the green key, which had the same VI 60-s schedule associated with it, was presented in either a rich or lean context (as denoted by the side lights).

In the backward phase, the procedure was identical except that this time the target response was red-key pecking. Regardless of which side light was on, this time pecking the red key produced food on a VI 60-s schedule. The green key served as the additional source of reinforcement in this phase. Recall that green always preceeded red, which this time was the target stimulus. If the left light was on (denoting the rich reinforcement context) green key pecking produced food on a VI 15-s schedule. If the right light was on (lean reinforcement context), a VI 240-s schedule was in effect. Thus, the green key schedule, or the additional source of reinforcement, was either rich or lean depending upon the side keys.

Baseline training in both the forward and backward phases was run until responding became stable (no upward or downward trend for three days). After responding became stable, tests for resistance to change were conducted. Different types of resistance tests were given in order to obtain replication. The resistance tests consisted of resistance to extinction and two types of satiation.

Extinction test. This resistance test consisted of a single session that ran until the bird failed to respond to eight consecutive trials. In all other respects, the procedure was the same as in baseline except that no food was ever presented.

Long-session Satiation test. This test consisted of running the baseline procedure, where the bird continued to receive reinforcement as long as he continued responding. The test was terminated when the bird failed to respond (presumably because the bird was satiated on food) for eight consecutive trials. These sessions lasted anywhere from 2-10 hours.

Short-session Satiation test. This method of satiation consisted of pre-feeding the bird differing amounts of food immediately before a shortened session. The amount prefed was 0g, 30g, 45g and, if needed, 52.5g of food in the bird's home cage over a number of successive days. The shortened session consisted of seven trials of each context randomly presented.

For one bird (Gary), an alteration was made in the procedure of one extinction test and one long satiation test. For this one bird, during two resistance tests, only the target key and contextual cues

were presented. The alternative reinforcement key was never presented. This type of resistance test provided a "purer" test. That is, all conditions were the same between the two target keys except for the presence of the contextual cues. Thus any differential responding to this target must have been a function of the contextual cue.

CHAPTER III

RESULTS FROM EXPERIMENT ONE

Dependent Measures

In both phases, for each 1.5 hour baseline session, an average response rate (responses per minute) was calculated. For extinction and long-satiation sessions, which tended to last several hours, response rates were obtained throughout the resistance test in order to see the change in behavior over the course of the change operation. The number of obtained response rate points depended upon the total number of trials the extinction or satiation test lasted. If the number of test trials was larger than 35, this number was divided by 5, and a response rate was obtained for each of the 5 blocks. If the number of trials that the resistance test lasted was less than 35, this number was divided by 4, and a response rate was calculated for each of these 4 blocks. (If 5 points had been used with less than 35 trials, each response rate point would have been based on few trials, resulting in a more variable function.) For the short satiation sessions, the obtained response rates in the lean and rich contexts were calculated over the entire session time (7 trials per component).

Baseline Data

In both the forward and backward phases, baseline sessions

were conducted for at least two weeks and until no upward or downward trend occurred for three consecutive days. Acquisition of conditional control was assessed by examining response rates during the alternative reinforcement schedule depending upon the side lights. Subjects differentially responded to the alternative reinforcement key in accordance with the available rate of reinforcement in effect on that key as indicated by the side light (high rate to the rich key, and a lower rate to the lean key). If differential responding had not occured to this key, resistance tests were not conducted. (See Table 1 for a list of response rates during the target and alternative keys in both contexts. Note: All tables can be found in Appendix D).

During baseline, the response rate to the target key, in both the forward and backward phases, was generally lower in the rich context than in the lean context, even though the rate of reinforcement during the target key was the same--a contrast effect. This effect during baseline was consistently found in three of the five birds, in the forward Phase and four of the six birds in the backward phase. Contrast, however, was not found consistently in two of the birds (Eric and Homer) in either phase. For these birds, differences in baseline response rate between the two target responses were more often either small or not evident.

Resistance Data

During the resistance tests, the target response rate in both the lean and rich contexts declined over time. The data from all the resistance tests, for each bird, from the forward phase are presented in Figure 4A and from the backward phase in Figure 4B. The mean response rate obtained during the resistance test (responses per minute) from each block of trials is plotted as a function of time (in arbitrary units). Response rates are plotted on a log scale to show relative changes from baseline. The left-most point in each graph is the pre-disruption baseline point obtained during the last day of baseline training prior to the resistance test. The open symbols are those from the lean context, and the closed symbols are from the rich context.

In the left column of Figure 4 A and B, the data obtained from the extinction test are presented, in the center those from long-satiation sessions, and in the right column are those from the short satiation procedure. Each panel represents one resistance test run. If replications were conducted, these are shown by additional panels in each column.

The data from both phases appear essentially the same. The graphs in Figure 4 A and B show that, for most birds, the slopes of the function for the target response are shallower in the rich context than in the lean context. In fact, in most cases, target response rate in the lean context begins at a higher rate (a contrast effect) but then, as more time is spent in the resistance test, response rates of

the target in the lean context drops below that of the response rates in the rich context (i.e., the functions cross), indicating less persistence for the former. In two birds (Eric and Homer), however, there was no reliable difference in resistance between the target responses.

The trend for all data obtained from each subject can be convienently displayed in a scatter graph that plots relative resistance of target behavior within the rich and lean contexts to the overall disruption of response rate (total response rate in the lean and rich contexts). In this plot, A_x is represents the response rate at each x point in time (shown in Figure 4) in the rich situation during the resistance test, C_x is the target response rate obtained from the lean context during the resistance test, and $A_B + C_B$ is equal to the the baseline target response rate from the rich and lean contexts, respectively, obtained the day prior to the resistance test. The ratio of $A_x/ (C_x + A_x)$ is plotted on the ordinate as a function of $(A_x + C_x)/ (A_B + C_B)$. Thus, the values on the y-axis represent the differential resistance between the two contexts, which is compared to the overall proportion of disruption from baseline. As the response rate declines overall (i.e., as $(A_x + C_x)/(A_B + C_B)$ decreases from 1.0), the ratio $A_x/(A_x+C_x)$, should be about .5 if the response is equally resistant in the two contexts. However, if behavior in the rich context is more resistant than behavior in the lean context, the ratio should rise above .5, indicating that as behavior is being disrupted, it is being disrupted more in the lean versus the rich context. In these

graphs, then, we expect a rising slope from right to left. Figure 5A shows such a scatter plot for each bird. The plots include data obtained from all three change operations in the forward phase. Figure 5B shows the same plots for the backward phase. Some birds participated in more resistance tests than others, and therefore have more points per plot. For most of the birds, the overall trend reveals that as the performance becomes more disrupted (proportion of baseline decreases), the ratio between $A_x/(A_x+C_x)$ increases, indicating greater disruption in the lean context as compared to the rich context. The functions of the data from two birds (Eric and Homer), though, reveal a relatively flat line.

The Pearson correlational coefficient (r) for each plot are shown in the upper right corner of each plot. Those starred are significant at the .05 level or less, based on treating the scatter as if each point were an independent observation. In the forward phase, in four of six plots the r's are significant. In the backward phase, three of the five r's are significant. Again, the same two birds (Eric and Homer) were the exceptions in both phases.

Another way to represent these same data is to calculate a p statistic for the target in each context. The p statistic, a weighted mean proportion reduction, summarizes in a single value resistance relative to baseline (Nevin, Mandell, & Yarensky, 1981). For each context, p may be obtained by dividing each value obtained during the resistance test by that context's baseline (or pre-disruption) value. These proportions are then given weights, with the first

resistance test point being weighted by 1, the second by 2, etc. Because the effects of a resistance test should become greater as time elapses, the latter values obtained from the disruption tests are weighted more than the earlier ones. The weighted proportions are then summed and divided by the total number of weights, in order to give a weighted average deviation from baseline. The formal expression of p is:

$$p = \frac{(1)\frac{D_1}{B} + (2)\frac{D_2}{B} + \ldots + (x)\frac{D_x}{B}}{1 + 2 + \ldots + x}$$

B represents the baseline value, while D_x is disruption value for time x (i.e., response rate during a disruption test at time x).

Thus, if there is no disruption in behavior, p should equal 1. The greater the behavioral disruption, the more p should fall below 1.

With D_x representing the target response rate obtained during each period of the resistance tests, a p value for each the target in each context (for each bird) was obtained from each resistance test. The p values from the lean context (p_l) was subtracted from the p value obtained from the rich context (p_r), resulting in a single value that expressed the difference between the two contexts in terms of resistance from baseline. If the target in the rich context was more resistant than the target in the lean context, these p-value

differences ought to be positive. These values from both phases are presented in Table 2 A and B. In the forward phase, 21 of 25 of these values are positive (two of the four negative values were from Eric and Homer). In the backward phase, 18 of 24 values are positive (with four of the six negative values also from Eric and Homer). Again, the data from three of the five birds in the forward phase consistently resulted in positive values, while the data from four of the six birds in the backward phase were positive.

While the majority of the p difference scores were in the expected direction, there were some runs (mainly from two birds--Eric and Homer) where there was either no difference or a difference in the opposite direction than was predicted between the resistance of the targets in the rich and lean contexts. While the effect was found reliably in three of the five birds in the forward phase and four of the six birds in the backward phase, the same two birds data consistently revealed no differences between the two contexts in either phase.

These two birds also did not show contrast consistently during baseline. It was suspected that the lack of differential resistance was related to a lack of contextual control. To assess this possibility, the relationship between the differential resistance found in a resistance test and some measure of contextual control in baseline was determined. The p difference values just described (and shown in Table 2) were taken to represent differential resistance between the rich and lean contexts. The level of contrast was taken as a measure

of contextual control. That is, if the contextual cues stood as a reference so that the rates of reinforcement during the red and green keys were relative to the rate of reinforcement signalled by the contextual cue, then we should see changes in target response rate as a function of the alternative reinforcement. As described earlier, contrast indicates that such a comparison had been made.

A correlation was calculated for the relation between level of contrast (the differences between baseline target response rates in the rich and lean contexts) before each resistance test, and differential resistance (the mean p-value difference between the two contexts). For each bird, an average p-value difference was calculated, as well as an average contrast value. In the forward Phase, the correlation coefficient obtained between level of contrast and the p differences values was $r=.99$, $df= 4$, $p < .0005$, (one-tailed). In the backward phase, with 5 subjects, an $r=.83$, $df=3$, $p < .05$, (one-tailed) was found. These correlations suggest a positive relationship between the amount of contrast and the size of the effect. Thus, enhanced persistence was more likely to be found when there was some degree of contextual control. (See Figure 6 for a plot of the level of contrast as a function of the p-value difference score).

CHAPTER IV

EXPERIMENT ONE DISCUSSION

Given that alternative reinforcement led to increased persistence in most birds (five of seven) in both the forward and backward phases, several conclusions may be drawn. First, the forward phase replicated past findings with a conditional discrimination paradigm, showing that the contextual cue may enhance persistence. The backward phase more explicitly and stringently showed that contextual cues may be the source of facilitation of a target response.

The rate of reinforcement available for pecking the alternative reinforcement key in both phases for most birds caused the rate on the target key to vary. This result suggests that the side lights did function as contextual cues for these birds, where the rate of reinforcement available during the red and green keys functioned relative to the context. In addition, the persistence of target-key responding varied with the presentation of the side lights indicating that these contextual cues facilitated resistance to change. The backward pairing paradigm in the backward phase minimized the additional facilitation (which results from signalling the added reinforcers) available from the TS^D, though differential persistence was still found. This suggests that the facilitation was indeed evoked by the contextual cues. Thus, the data support the analysis of the

enhanced persistence effect based on the relativistic conception of conditioning described earlier.

While the procedure of this experiment was sufficient to generate the effect reliably in most birds, it was insufficient to produce the effect in two birds. The correlations calculated between level of contrast and p-value differences may shed some light on this aspect of the data. In both the forward and backward phases, when contrast was not present, target responding was unlikely to be differentially resistant between contexts. For example, the two birds (Eric and Homer) whose data did not show enhanced persistence in the rich context, did not consistently show contrast during baseline. This may suggest that birds who did not show contrast were somehow not under the same environmental control as the other birds--that is, the contextual control that was necessary to find enhanced persistence. Perhaps, for example, the side key and the center key functioned as compound stimuli for these birds (e.g., the four separate stimuli were green and right light, green and left light, red and right, and red and left). That is, it may be that for these two birds, the side lights did not function as a contextual cue, where the rates of reinforcement during the two key colors were relative to the side light as a contextual cue. Based on the relativistic conditioning analysis, it would be expected that if a contextual cue function had not been formed, neither contrast nor enhanced persistence should be found.

Suppose that instead of the formation of two contextual cues,

Suppose that instead of the formation of two contextual cues, each color and side light presentation functioned as a compound TS^D. That is, there are actually four distinct stimuli within a single context (as defined by the chamber cues): green and the right light, green and the left light, red and the right light, red and the left light. The rate signalled by each TS^D compound was compared to the overall average rate of reinforcement in the chamber. Compared to this average, the rate signalled by the rich alternative reinforcment key is relatively good, while that signalled by the lean alternative reinforcement key is relatively poor. The rates signalled by the two target key compounds, however, are equally good. This is because both of the target compounds have equal rates of reinforcement associated with them and are compared to the same overall context. Thus, the evocative effect of either target compound would be the same. If this occurred in the present study, then response rate (i.e., contrast level), and resistance between the two targets should not differ, as was found with two of the seven birds. Thus, the account of the data based on the notion of relativistic conditioning appears to be supported by the data.

Nevin (1990) recently described a set of data that also supports the analysis based on the conception of relativistic conditioning. He arranged a multiple schedule, where a target and alternative reinforcement source alternated during the session. In one context, the alternative source, had a rich rate of reinforcement (which was a

higher rate than the target source) associated with it. This context was run in isolation, and then resistance tests were conducted. After these tests, the second context, where the alternative reinforcement source was lean (the rate of reinforcement was lower than the target rate), was run in isolation for a period of time followed by resistance tests. The target key always had the same rate of reinforcement associated with it. Thus, in Nevin's procedure, the two contexts (composed of a target and alternative source pair) were not alternated with one another in close temporal proximity. What was found was the opposite of what was reported here--target responding associated with the lean alternative reinforcement was **more** resistant than target responding associated with the rich alternative reinforcement. Rate was also higher in the lean alternative reinforcement context than the rich context (i.e., a contrast effect was found).

The most striking feature of Nevin's procedure is that the two contexts were not closely alternated with one another, as they were in the present experiment. In Experiment 1, each context (as defined by the side lights or contextual cues) had common features (e.g., the chamber cues). The chamber cues signalled the average rate of reinforcement available from all sources in the session. The rate of reinforcement signalled by each contextual cue could be compared to the chamber cues. Thus, the side light which signalled the rich context would become more evocative than the side light which

signalled the lean context. It is this comparison which leads to the contextual cues to become more or less evocative.

This comparison that could be made in Experiment 1, could not occur in Nevin's procedure (1990) because the two contexts were run in isolation. Instead, in each isolated context, the target and alternative sources shared a common feature, the experimental chamber. In the lean context, the chamber signalled the average rate of reinforcement available from the target and the lean alternative source. Relative to this rate, the rate signalled by the target stimulus was better, which would lead to the target stimulus becoming more evocative. In the rich context, the chamber cues signalled the average between the rich alternative source and the target. Relative to this context, the rate signalled by the target was now poorer. Thus, the evocative strength of the target stimulus in the lean context would be greater than the target stimulus in the rich context. During a resistance test, the target stimulus with the greater evocative effect could facilitate persistence.

But the contextual cues in each isolated context (the chamber cues) were not compared to anything else, and thus in this procedure there seems not to be the additional facilitating effect resulting from the contextual cues. (Recall that the excitatory effect evoked by the contextual cues opposes the effect evoked by the TS^D. Thus, the resultant effect is likely to be a summation of all evocative effects.)

The question which may remain is why there were individual differences in how the stimuli functioned or were "perceived" by the pigeons. That is, for most birds, the side lights functioned as contextual cues. For two birds, however, the stimuli may have been perceived as compound TS^D. Past environmental history, no doubt, plays a major role in how stimuli function or are perceived. There may be changes, though, which can be made in the procedure which would reduce the chances that the stimuli would function as compounds. First, one procedural change may be to keep the side lights on during the time-out to reduce the chance that the side lights and center keys would form a compound. Second, the time between the presentation of the alternative source and target source may be reduced so that it would be more likely that these two sources would share the same feature. Finally, the context cues could be made more salient (e.g., have different chamber wallpaper associated with the different contexts).

Finally, given that multiple schedules, instead of concurrent schedules, were used in Experiment 1, such interpretations as melioration or misattribution would be unlikely explanations for the present data (See Appendix C). It appears that enhanced persistence is probably due to other variables, such as the overall rate of reinforcement in the situation.

CHAPTER V

INTRODUCTION TO EXPERIMENT TWO

Experiment 1 provided support for the hypothesis that contextual cues can facilitate persistence. The purpose of Experiment 2 was to further examine the generality of this effect--that is, the finding that enhanced persistence results from alternative reinforcement. Can the effect that was demonstrated with pigeons be found across paradigms and species? In addition, Experiment 2 examined whether the facilitation evoked by the context is general across reinforcer types.

Replication with Humans

Thus far, the experimental studies which found enhanced persistence given an alternative reinforcement source examined the keypecking response of pigeons. Keypecking, however, has been shown to be highly influenced by Pavlovian processes (Locurto, Terrace, & Gibon, 1981). Thus, it is possible that the effect of Pavlovian contingencies on the persistence of keypecking is not a general effect on operant behavior. It would be important, then, to see if alternative reinforcement has a similar effect on the persistence of operant behavior in other species. Since we are ultimately interested in human behavior, it would be most useful to know if the effect can be demonstrated with humans.

Alternative reinforcement was found to enhance the persistence of a discrete response in two retarded adult males (Mace, Lalli, Shea, Lalli, West, & Nevin, 1990). In this study the subjects sorted eating utensils (spoons in the spoon bin, forks in the fork bin, and so forth). During some periods, the utensils were red; at other times, they were green. The point of the color was to create two different stimulus conditions (or contexts). The rate of reinforcement contingent on sorting was the same during both colors. However, during the sorting of one of the color utensils, the subject was given alternative reinforcers (these reinforcers were of the same type as the scheduled reinforcers--coffee for one subject, popcorn for the other) delivered at any time when the subject was not engaged in sorting behavior. To test the persistence of utensil-sorting, the experimenters occasionally turned on a TV in front of the subjects while they were performing the task. Sorting of utensils was less susceptible to distraction by the TV during the sorting of the color utensil associated with the extra reinforcement. Thus, the Mace et al. finding is an important one in that it found enhanced persistence, as a result of an alternative source of reinforcement, with **humans** using **distraction** as the change operation.

In both the Mace et al. study and the previous studies conducted with pigeons (including Experiment 1), the persistence of a **discrete** response was examined. However, much interesting human behavior (such as relaxing) is not discrete. It would be important to replicate the Mace et al. findings and to further extend

them to a fluid human behavior. One focus, then, of Experiment 2 was to examine the persistence of such a response.

Reinforcement Type

A second focus of Experiment 2 concerned the generality of the excitatory effect evoked by the contextual cue. In previous studies, the additional reinforcers delivered have been of the same type as the reinforcers given for the target response. For example, if the pigeon was given food for pecking the target key, the additional reinforcement given freely or contingent upon a second response was also food. In this situation, a context made excitatory through signalling a given reinforcer type (such as food) enhanced the persistence of a response reinforced by the same reinforcer. But, can a context made excitatory through signalling a given reinforcer type (e.g., food) enhance the persistence of a response that was reinforced with a different reinforcer type (such as water)?

In fact, data from several studies (not explicitly examining persistence) suggest that the target and additional reinforcement sources might need to be similar in order for a context to facilitate a response. For example, Rescorla and his colleagues, who have been interested in examining the motivational properties of excitatory stimuli on behavior, found that the ability of an excitatory stimulus to influence a response depended upon the stimulus and response sharing a common reinforcing outcome (Rescorla & Colwill, 1989). Williams (1989) found that response rate dropped more when

alternative reinforcement of the same type as the target reinforcement was given than if additional reinforcement of a different type was given. Thus, it appears that the response-reinforcer and stimulus-reinforcer associations are specific ones.

Theoretically, the notion of response class (Skinner, 1953) might also suggests that reinforcement type could be an important consideration. A response class is a set of behaviors functionally tied together as a result of each producing the same outcome, or the same reinforcer type. One consequence of members of a response class sharing a common outcome is that these members will be similarly affected by motivational variables with respect to that outcome. For example, the behavior "opening the refrigerator door", "dialing Domino's pizza" or "hunting" may be functionally tied together as "food obtaining" behavior when all three are done for the "purpose" (or maintained by the consequence) of obtaining food. Each member's probability of emission will co-vary with the other in relation to certain motivational variables with respect to food. That is, the probability of "food-obtaining" behavior will increase with food deprivation but decrease with satiation. Reinforcing any one member of a response class may decrease the rate of other members of that class (e.g., if you find pizza in the fridge, you might not call Domino's), but perhaps reinforcing one member has an effect on the persistence of all members. That is, if you've been reinforced in the past by food, then there may be an increase in the persistence of any

behavior which produces food. Suppose, for example, the phone is busy when calling Domino's, you might persist in calling. Or if you discover that the phone is out of order, you might cook a pizza from the freezer, even if you are tired.

The Pavlovian effect, described above, can be considered a motivational variable. There are several ways to think of a motivational variable. We may call a variable motivating if it alters the reinforcing effectiveness of some event and if it alters the rate of operant behavior that has been reinforced by that event (e.g., Micheal, 1982). Food deprivation is an example of such an establishing operation. In the present research, it may be that the effect evoked by the contextual cue is analogous to an effect of deprivation. For example, if the contextual cue signals food presentations, then perhaps the motivational effect evoked during extinction is analogous to hunger and may lead to an increase in the rate of behavior that had been reinforced by food. This implies that if the contextual cues signal a different reinforcer type (e.g., water) than the target source (e.g., food), then during extinction the effectiveness of water as a reinforcer will be altered. Given that the target is reinforced by food, the excitatory effect evoked by the contextual cues may not facilitate persistence. This conception that the excitatory effect (or motivational effect) evoked by the context is specific to reinforcer type follows from the response class hypothesis.

Another possibility is that the excitatory effect evoked by the context may be general with respect to reinforcer type. That is, all

types of reinforcers may result in a stimulus becoming excitatory. The excitatory effect of the stimulus may be a generalized arousal state. That is, a stimulus made excitatory by its signalling a given reinforcer type may facilitate a response that is reinforced with a different reinforcer. The arousal effect evoked leads to incresed activity, with the form of the response being dictated by the operant contingency.

It should be mentioned that the Pavlovian hypothesis examined in Experiment 1 does not inherently lead to a differential prediction with regard to reinforcement type. That is, it may be that the excitatory effect evoked by a stimulus (with the S^D or the contextual cues) may be general or specific to reinforcement type.

Practically, if different types of reinforcers can be used to enhance persistence, then the utility would be greater. Suppose, for example, in school a child receives A's for doing his math problems. To increase the persistence of this behavior without explicitly increasing the reinforcement rate for his math work, maybe one could give reinforcers for other behaviors in the environment. Such reinforcement may be varied and different from that given for doing math (e.g., social praise for his manners, break-time snacks for good behavior) In fact, clinicians often use a variety of reinforcer types. During talk therapy, for example, reinforcement varies from overt praise to such subtle reinforcement as the continuation of a conversation.

Thus, the second question addressed by Experiment 2 is: Does the alternative reinforcement have to be the same type as the reinforcement for the target to enhance persistence, or can the enhancement effect be found when the alternative reinforcement is of a different type?

Operant Research with Humans

Research with humans poses special challenges to control sources of variability. In using humans, it is critical to be aware of the uncontrolled sources of variability which may obscure the general findings. More specifically, the verbal capabilities of a human can result in uncontrolled contingencies in the laboratory. The potential functional components of verbal stimuli (e.g., discriminative, instrunctional) have long been recognized (Skinner, 1957). Instructional control and self-rules can compete with the contingencies arranged by the experimenter. Given that the history behind self-rules is likely to be very long, the resulting behavior often has a higher probability of emission than the behavior generated by the experimental conditions. This is not to say that behavioral processes are not working, but rather that there is less control over the pertinent contingencies.

There are several ways to bypass contingencies arranged by the client's own verbal responses so that the observed responses are a product mainly of the contingencies arranged by the experimenter (both verbal and otherwise). One is to use pre-verbal individuals or

individuals with limited verbal capabilities (as in the Mace et al. study). The second is to examine a response that is not (or is minimally) affected by verbal stimuli because the individual does not have the ability to talk about it (i.e., responses which are outside of "awareness"). The present experiment took this latter route by examining "relaxation" as measured by a biofeedback apparatus.

In addition to measuring and recording the impulses and activity that represent changes in heart rate, temperature, and electromyography (EMG) level, the biofeeback apparatus also arranges contingencies for changes in these measures to occur. The feedback (either visual or auditory) is an effective consequence for changes in such measures as EMG level. Often subjects are unaware of the contingencies altering their behavior, nontheless, such contingencies are effective.

In Experiment 2, subjects were trained to decrease muscle EMG, as measured by a biofeedback apparatus. In order to determine whether alternative reinforcement can enhance the persistence of the "relaxation" response, an alternative reinforcement source was made available in one of two contexts. The persistence of the target response in this context was compared to the persistence in a second context where no alternative reinforcement was available. If the finding that additional reinforcement leads to an enhancement of behavior is a general one, then the context with added reinforcers should result in a more persistent target response than the context without the added reinforcers.

In addition, there were two phases in this experiment. In one phase, the alternative reinforcement was of the same type as that received for the target response. In the other phase, the alternative reinforcement was different from the target reinforcement. If the excitatory effect evoked by the context is specific to members of the same response class, then enhanced persistence should only be found when the additional reinforcement is of the same type as that for the target response. But if the excitatory effect evoked by the context is not specific to reinforcement type, then enhanced persistence should be found regardless of the type of alternative reinforcement given.

CHAPTER VI

METHOD OF EXPERIMENT TWO

Subjects

Thirteen children (10 boys, three girls), 7-12 years old (mean age=9.3), were recruited from the community through a newpaper advertisement worded:

"Children needed for study at UNC-G on relaxation. Prizes will be awarded. Please call...".

Each subject was assigned to one of two treatment orders. Six of the subjects were first exposed to Phase-same, where the alternative reinforcement was the same as the reinforcement for the target response. The other seven subjects first participated in Phase-different, where the alternative reinforcement was different from the target reinforcement. Each subject's parent was asked at the conclusion of the experimental session if the experimenter could call him/her in a couple of weeks to see if the child would be willing to participate in another experimental phase. All parents were willing to be called. All subjects except three participated in both phases. One subject participated as a pilot subject for Phase-same, and his data from this phase were not included in any analysis. Another subject was only in town for a couple of weeks and could not participate in a second phase. A third subject misunderstood the

instructions for the first phase in which he participated, thus his data from that phase was discarded.

Apparatus

The biofeedback apparatus utilized was the UNC-G Psychology Clinic's Cyborg Biolab apparatus which is connected to an IBM computer. The computer operates the Biolab machine and records and displays data. The module used was the EMG module, which records and amplifies the small electrical activity generated by muscles. Auditory feedback was provided when EMG levels decreased below a criterion.

Procedure

When the subject entered the laboratory he/she was seated in a large reclining chair and was told about the biofeedback machine in front of him/her (see instructions below). Electrodes were then placed directly on the skin above the masseter muscle in his/her neck. In front of each subject was a box with two lamps with colored caps (e.g., green and white). Beneath each light was a counter, and beneath that was printed the word of the color of the light written in the corresponding color of ink (e.g., beneath the green light was a counter labeled "Green", written in green ink). (See Figure 7 for a diagram of the apparatus.) The subjects could not see the computer screen, which graphed the biofeedback data moment by moment, nor the controls for the lights and counters.

Six of the subjects first participated in and heard the instructions during Phase-same, while the other seven subjects first participated in and heard the instructions during Phase-different. When subjects returned for their second participation after several weeks, the instructions were repeated to remind them of what was required. The instructions given were:

"This machine is called a biofeedback machine. It's run with a computer. Do you have a computer at home? This machine can measure the signals your muscles send when they are relaxed or tense. All I want you to do is relax. This machine will tell you how well you are relaxing. When you are really relaxed, the machine will beep. For every three seconds that the beep is on, you'll get a point. You can see how many points you get by looking here (point to counters). You may be wondering why there are two different color lights here. Well, when the white (for example) light is on, you will earn points just like I described. When the green (for example) light is on, you'll also earn points like I described but in addition, once in awhile you'll get free points (note: in Phase-different candy was replaced for extra points) just for nothing. These free points (or candy) are not for anything you do, that's why they're free.

It may take a while for you to relax that neck muscle. Sometimes different head positions are better than others to get that muscle relaxed. So you may want to try different positions until you find that one position that helps you relax.

After we're done you will get play dollars in exchange for the points you've gotten. The more points you earn the more dollars you get. You will get dollars for each color's points separately--you can't add the points together from the two colors. Then you can use the dollars to buy any of these toys (Toys are in clear view). The toys are different prices. Are there any questions?

An initial trial lasting 30 sec., without the possibility of the tone sounding, was conducted to obtain the subject's muscle tension level before training. The criterion (i.e., the EMG level which when attained would lead to the sounding of the tone) initially was set at 3 mv. If the subject's pre-training EMG level was lower than the 3 mv criterion, or only higher than the criterion by 2 mv or less, the

criterion was decreased. The final criterion was always set at 1.5-2 mv below the subject's pre-training EMG level in order to allow room for decreases in EMG levels to occur as a result of the operant contingency. After the pre-training trial, the tone module of the biofeedback machine was turned on, and one of the two colored lights came on. For the subjects who participated in Phase-same second, a white light signalled the context without the added reinforcers, while a green light signalled the context with the added reinforcers. For those who began with Phase-different, blue signalled the context without added reinforcers, and red signalled the context with added reinforcers. During Phase-different, the light colors were changed to two new colors the subjects had not seen before. For those who received Phase-different second, these were red and blue for the context without and with added reinforcers respectively, and for those who got Phase-different first, these were green and white, respectively. (There were exceptions to this color switch rule for those subjects who got Phase-same first. In two of these cases, the original lights were switched. In another case, the color signalling the context without added reinforcers remained the same, but the color signalling the context with alternative reinforcement was changed).

The experimenter warned the child at the start of each trial by saying "ready". Each color light remained on for three consecutive trials, with each trial lasting thirty seconds. At the end of each 30-s trial, the number of points earned was counted out on the counters

as the subject watched. This counting of the earned points took approximately 30 seconds, after which the next trial immediately followed. At the end of a three-trial color block, another three-trial color block of either the same color or of the other color began. The order of presentation of the three-trial color blocks was randomly generated with the rule that a block could only be presented two times in a row. This order of presentation was the same for all subjects. In Phase-different, the order of presentation of the two contexts was the mirror image of that in Phase-same (that is, if the third color block was a context with alternative reinforcement during Phase-same, it was a context without alternative reinforcement during Phase-different, and vice versa). Baseline sessions consisted of eight three-trial-block presentations of each color, which resulted in a total of 48 trials. This baseline training lasted approximately one hour.

In both phases, the number of points earned was contingent upon the percent of time the tone was on during a 30-s trial. That is, if the tone was on 0-4% of the 30 seconds, the child received 0 points; 4-14% of the time, 1 point; 15-24% of the time, 2 points; 25-34%, 3 points; 35-44%, 4 points; 45-54%, 5 points; 55-64%, 6 points; 65-74%, 7 points; 75-84%, 8 points; 85-94%, 9 points; and more than 94% of the time, 10 points. Thus, the most points that could be earned on any given 30-s trial was 10.

In Phase-same, the alternative reinforcement was of the same type as the target reinforcers--that is, points. Free points were

delivered after the first and second trials of each three-trial color block, but only during the specified color (e.g., green or red). The free points were counted out after the earned points were counted, and were introduced as "free" throughout the experiment (e.g., "you earned two points that time: one, two. And you get 10 free points for being in (e.g.,) red: one, two..."). The number of free points given was either 5 or 10, with the amount given on the pre-determined trials alternating between these two amounts.

In Phase-different, the alternative reinforcement was candy (instead of free points), and was given again after the first and second trials within each three-trial color block of the designated color. Each subject was given a paper bag in which the experimenter put the candy. Children did not eat the candy during the experiment and could not choose the candy they received. Subjects still earned points for "relaxing", and these points were counted out after each trial as before. The candy was given after this counting of earned points and was introduced as free throughout the session (e.g., "you earned two points that time: one, two. And you get a piece of candy for being in (e.g.,) red"). Candy given out included: Hershey Miniatures, Reeses Peanut Butter Cups, Charms Blow Pops, Starburst fruit candy and Knutts chocolate. (See Figure 8 for a diagram of the procedure in Experiment 2).

Resistance Test

At the end of the baseline training, the subject was told that the

audio feedback would be turned off. He/she was also told that points (earned and free) and/or candy would still be accumulating but that he/she would not find out how many points and candy had been obtained during this part until the end. The subject then received 14 "quiet" trials, with the tone module off. The colored lights were still illuminated, and the subject was told to continue to watch those lights to see in which context they were. During the resistance test, a light was on for only one trial at a time before a color change, with the two colors alternating over the 14 trials. The first color of each test was randomly determined for each subject.

There was a specific reason for eliminating just the audio feedback (and not the points) during the resistance test. It was assumed that the audio feedback reinforced and maintained what will be called the "relaxation response", consisting of behavior that resulted in decreased EMG levels (e.g., the positioning of the head, closing eyes, holding breath). The tone was also a conditioned reinforcer, due to its association with points (and ultimately toys), for what may be called task responses (e.g., sitting in the chair, looking at the lights, complying with the instructions and the demands of the task). The main reinforcers for these responses, however, were the points (and toys). Such task behavior was necessary to perform the target behavior of "relaxation". That is, if the subject did not sit still, muscle tension could not decrease. During the resistance test, the conditions were set for the relaxation response to extinguish because all feedback for performance (the audio feedback and the points)

was eliminated. It did not, however, remove "motivation" to perform the task because task behavior was still being maintained by the points. If all reinforcement had been removed, it was feared that extinction would have occurred almost instantaneously (i.e., subjects would quit trying), producing a floor effect.

Thus, the subjects continued to comply with the instructions. Without the feedback guiding their responses, however, it became more difficult for the subjects to decrease EMG levels. In addition, it was apparent that children began to become bored or fatigued within the hour of training. Any disruption in subject's performance was due to both extinction (removal of all feedback) and disruption (due to fatigue).

At the end of the resistance test, subjects were given the points they had obtained during the test. The total points (for each color separately) were then translated into play dollars (50-149 points=$1, 150-249=$2, etc.). The child was then allowed to purchase what he/she wanted. Toys ranged from $1 to $3. Toys were such items as Ninja Turtle squeeze bottles, New Kids on the Block paraphernalia, stickers, cars, baseball cards, etc. All children earned at least a total of $3 during Phase-same, while the most earned was $5. During Phase-different, subjects earned at least $1, and the most earned was $3.

It should be noted that with this procedure there is a concern that experimenter bias may have been a subtle influence on behavior. The experimenter was keenly aware, however, of potential

biasing influences and took special care to avoid any influences. First, subjects asked questions throughout the experiment. Standard responses were constructed for the most frequently asked questions during pilot testing. (For example, "How much longer?" Response: "It won't be long". "How am I doing?" Response: "We'll talk later"). These same replies were given to a variety of questions. Second, the identical "ready" signal was given before each trial in as similar a vocal tone as possible, as was also the vocal delivery of the points. Third, while body position and facial expression may be the greatest sources of bias that are least under the conscious control of the experimenter, those sources do not appear to have been likely influences. All subjects remained with their eyes closed during the "relaxation" and only opened them between trials to glance up to see which color light was lit. In addition, the child's view of the experimenter was partially blocked by the experimental apparatus. Finally, the experimenter also attempted to breathe consistently and in the same rhythm and to avoid making any noises, such as coughing or sighing, throughout the conditions.

CHAPTER VII

RESULTS FROM EXPERIMENT TWO

Dependent Measures

Two dependent measures were taken. For each 30-s trial, a mean EMG level in millivolts (averaged over the thirty seconds) was given. The lower the EMG level was, the more relaxed the muscle was. For most subjects, EMG levels remained stable across both phases of this experiment. Correlations were computed for EMG level in the control contexts between Phase-same and Phase-different. An $r=.59$ was found, $df=10$, $p<.025$ level, (one-tailed). Also, a similar correlation was also computed for EMG level in the context with alternative reinforcement between Phase-same and Phase-different. An $r=.61$ was found, $df=9$, $p<.025$ level, (one-tailed).

The second dependent measure was the percent (%) of time the tone was on (i.e., the percent time the subject performed at or below criterion). For each dependent measure, the three data points from each three-trial color block were averaged to produce a single value for each block. In all, there were16 blocks (8 of each color). The values from the last 4 of the 8 color-blocks were again averaged to produce a single number representing the pre-disruption baseline value. (The first 4 values of baseline were not included in this average because of the great variability during initial acquisition.)

This pre-disruption baseline average was to be compared with performance during the resistance test.

Baseline

In both phases, subjects reliably acquired the response. That is, subjects generally decreased their EMG levels significantly below that of their pre-training EMG level as a function of the operant contingency. A t-test was computed on the differences between the pre-training EMG levels and the average EMG level during baseline in both phases. For Phase-same the mean difference between the pre-training EMG level and the average baseline level was 2.5, $t=5.32$, $df=11$, $p < .0005$, one-tailed. For the second dependent measure, % time, the mean difference between the pre-training % value and the average baseline value was 26.19, $t=4.1$, $df=11$, $p< .005$, one tailed. In Phase-different, the mean difference between initial EMG level and acquired level equalled 2.4, $t=4.70$, $df=10$, $p < .0005$, one-tailed. Again, for the second dependent measure, the mean difference between initial % time and the acquired level was 27.48, $t=2.88$, $df=10$, $p < .01$, one tailed.

During baseline in Phase-same, higher EMG levels were observed in the context with alternative reinforcement in five of the 12 subjects. The mean difference in EMG between the two contexts was .006, which was not significant ($t=.04$, $df=11$, NS). Similarly, the mean difference between the two contexts with regard to % time was .2 ($t=.1$, $df=11$, NS). Thus, unlike what was found with the bird data,

a contrast effect between the two contexts was not reliably found in the human subjects. In Phase-different, the mean difference in EMG levels between the two contexts was .38, (t=1.35, df=10, NS), and 3.89 for the % time data (t=1.25, df=10, NS). Thus, contrast was also not reliably found in this phase (only seven of the 11 subjects showed a decrease in performance in the context with alternative reinforcement as opposed to the context without added reinforcers).

Resistance Data

Fourteen disruption trials were given, seven of each color. Again, the dependent measures were EMG level (in mv) and % time spent at or below criterion. The data from the first trial of each color were not averaged with the data from any other trial because the first trial point was assumed to represent initial disruption. The remaining six points per component were averaged over blocks of two trials to produce three more disruption test points for each component. Thus, there were four points per component from the resistance test.

In order to show the overall trend of the EMG and % time data obtained from all subjects during the resistance test, an "average person" graph is plotted in Figure 9. Each point in this graph is the average of the logarithms of the dependent variable obtained from all subjects, regardless of order. In Figure 9A, the mean log EMG level obtained during the disruption test is plotted as a function of time. Recall that higher EMG levels indicate greater disruption. In

order to keep the direction of the curve consistent with the usual trend in extinction (e.g., a falling curve) and consistent with the direction of the graphs of the bird data shown above, the reciprocals of the raw data are plotted. Since the y-axis is logarithmic, taking the reciprocals of the data simply reversed the direction of the curves, but did not alter them in any other way. In these graphs, the greater the disruption, the more steeply the curve should fall. Figure 9A also shows the same type of graph only with the logged mean % of time spent engaged in the task plotted as a function of time.

The first, left most, point is the pre-disruption point averaged from the baseline data. In Phase-same, for both dependent measures, there are no differences between the two contexts (either with or without reinforcement) during baseline. Yet, as the resistance test proceeds, responding in the context without alternative reinforcement drops more.

The data from Phase-different are shown in Figure 9B. For both dependent measures, there does seem to be a difference in initial EMG level and % time spent on task during baseline. However, this difference is not a reliable one. The initial point from the disruption test reveals a greater drop in responding in the context with added reinforcement than in the context without the added reinforcers. As the disruption test proceeds, however, the two functions cross (as seen in the bird data earlier) so the EMG level (or % time value) in the context without the added reinforcers drops below that in the context with the added reinforcers. Performance declines in the

context without the added reinforcers, while there is little disruption in the context with the added reinforcers. Thus, in both phases it appears that persistence of the target response was enhanced in the context where alternative reinforcers were available.

To test the reliability of these data, a two-factor repeated-measures analysis of variance (ANOVA) was performed. Each factor was within subjects, with Factor A representing the context (either with or without alternative reinforcement) and Factor B representing time in the resistance test, beginning with the baseline value. A x B represented the interaction between these two factors. The clearest results would be to find an interaction between the two factors. That is, there should be little difference in performance between the two contexts early in the resistance test. As the test proceeds, however, differences in performance between the two contexts should become evident. The results of this test are shown in Table 3A for Phase-same and 3B for Phase-different. For both dependent measures in Phase-same, a main effect for context was found. As is seen in Figure 9A, there is a separation in the two functions during the initial disruption point, and the two functions remain separate. In Phase-different, the analysis on both dependent measures revealed a significant A x B interaction. With these data (seen in Figure 9B), the functions cross one another, resulting in an interaction.

Further statistical analyses were conducted to clarify the reliability of the effect. As with the birds, a p value was calculated for both dependent measures in both contexts, with and without

additional reinforcers, for each subject. These values are shown in Table 4 for both phases.

The p from the context without alternative reinforcement was then subtracted from the p attained from the context with alternative reinforcement. This yielded a p difference score for each subject for both dependent measures. A t-test was conducted on these differences.

For the EMG data from phase-same, the mean p difference was .18, with t=4.06, df=11, p<.005, one-tailed. Likewise, for the % data, the mean p difference was .17, t=2.11, df=11, p<.05 one-tailed.

In Phase-different, t-tests on the differences between p values between the two contexts revealed a similar pattern. For mean EMG level, the p difference between the two contexts was significantly different; the p difference mean=.18, t=2.13, df=10, p<.05, one-tailed. For the % data, p difference mean=.16, t=2.67, df=10, p<.025, one-tailed.

Since it is not known if the underlying distribution of the p difference means is normal, a non-parametric test which does not assume a normal population may be a more appropriate test with these data. The Wilcoxin was chosen because of its power in detecting both direction and quantity. The results of the Wilcoxin were similar to those of the t-test for both phases. In Phase-same, the EMG data revealed a T=2, N=12, p<.005, one tail. For the % data, T=16, N=12, p<.05, one-tailed. In Phase-different, a T=5, N=11, p<.005, one tailed was found for EMG data level. For the % data, a

T=6, N=11, p<.01, one tailed, was revealed. Thus, all analyses supported the conclusion that enhanced persistence of the target response was found in the context where alternative reinforcement was available.

For the individual data, see Appendix E. For each subject (in each phase), the logged reciprocals of the EMG levels obtained in the resistance test are plotted as a function of time. The logged % time values are also plotted. In the individual data, the variability between subjects becomes apparent. For example, subject # 6 clearly shows enhanced persistence in the rich context, in both phases, while subject #10 shows little or no differential persistence between contexts in either phase.

As stated, there were some cases where there was no differential resistance between the two contexts. As seen in Experiment 1, not all subjects showed differences in persistence dependent upon the context. With the bird data, it was found that there may be a relation between p value difference and level of contrast. Thus, with the human data a correlation was also obtained between the difference in EMG levels obtained in the contexts (with and without alternative reinforcement during baseline) and the p difference values. For the data in Phase-same, an $\underline{r}$=.79 was obtained, df=10, $p < .005$, (one-tailed). For Phase-different, an $\underline{r}$=.87, df=9, $p < .0005$, (one-tailed) was found. As with the bird data, this correlation suggests that there is a positive relationship between

contextual control and differential persistence. (See Figure 10 for the scatter plots of these data).

CHAPTER VIII

EXPERIMENT TWO DISCUSSION

The findings of both phases in Experiment 2 are similar to those obtained in Experiment 1 with pigeons as subjects, as well as those obtained with retarded adults (Mace et al., 1990). That is, additional reinforcement in a context increased the persistence of an operant response in that context. The present study further extends previous research in several ways. First, enhanced persistence was replicated on a human population, this time with normal children performing a fluid response. Second, the effect was replicated when the alternative reinforcer was a different type from the reinforcer given for the target. Thus, the effect does not appear to be specific to species, behavior type, or reinforcement type.

The size of the effects found in Experiment 2 was small, and the data were variable. It seems appropriate, then, to question whether these results are practically significant. That is, does the effect examined here really make a difference in the "real world". It may be expected the size of the effect described here (regarding enhanced persistence) may be greater outside the laboratory. First, procedural constraints and limitations may have resulted in the variable and small differences. Unlike the procedure with the birds, the training session and extinction trials were limited, because daily sessions could not practically be conducted with the children. If daily

sessions were held, as with the birds, the effect seen may be greater and less variable.

Secondly, as discussed in the Introduction, it is more difficult to control sources of variability when examining humans as opposed to when studying birds. For example, it may have been very exciting to many of the children to spend time at the university. Such excitement may have resulted in an effect which may have tempered the differences between the two contexts.

Despite the small effects, a consistent pattern did emerge. That is, both dependent measures revealed a similar pattern in Phase-same, suggesting that enhanced persistence is a result of an alternative reinforcement source. In addition, this finding was replicated in Phase-different, where again both dependent measures yielded consistent results.

Earlier it was hypothesized that the enhancement of persistence was due to a Pavlovian conditioning effect. That is, contextual cues become evocative as a result of signalling an average rate of reinforcement, relative to the average rate of reinforcement in the overall context. The purpose of Phase-different was to determine how specific this excitatory effect may be. That is, could contextual cues enhance the persistence of a target response if the contextual cues and target behavior do not share a common reinforcing outcome?

One argument presented was that the alternative and target sources of reinforcement might consequate different members of the same response class. Response class members are said to share some common properties, such that they co-vary with regard to motivational variables and that the reinforcement of one member of the class increases the strength (persistence) of all members. For example, in Phase-same, children obtained points both from the target and alternative reinforcement sources. All "point-behaviors" (which in this case included "relaxation"), as members of a single response class, may have increased in persistence with each point delivered. In Phase-different, there were two separate response classes, "point-obtaining behavior" and "candy-obtaining behavior". The different reinforcer, candy, should have had no effect on the persistence of "point-obtaining" behavior. Yet, the results from Phase-different indicate that alternative reinforcement available in a target context serves to increase the persistence of a target behavior in that same context, regardless of whether the alternative reinforcement and target sources of reinforcment are of the same type. This result seems to suggest that the response-class hypothesis can not adequately account for the data.

As described in the Introduction, the excitement evoked by the context may be a more general one, something like a general activation state. We know that a CS can elicit a specific CR. But suppose another effect of pairing a CS and reinforcement is that the CS can elicit a non-specific effect--akin to "arousal". This general

excitement may be a common effect of a large number of reinforcers. The contextual cues can evoke this non-specific arousal which can enhance the persistence of any behavior. The data from Phase-different appear to support this interpretation.

It is possible, though, that candy and points were actually functioning as similar reinforcer types. For example, although topographically different as objects, candy and points may both function as "goodies" or as "praise" (e.g., obtaining a point or a piece of candy functionally "means" that one has done well). If so, candy and points would be members of the same functional class with respect to reinforcers. If this is the case, then it would be difficult to say that the enhanced reinforcement effect can be brought about using different functional reinforcer types. At the least, however, the data obtained in Phase-different allows one to conclude that enhanced persistence is found when using topographically different reinforcers.

Indeed, it would be difficult to determine empirically if two reinforcer types are functionally different. In addition, when one thinks of a reinforcer class such as "praise", the number of functionally similar reinforcer types which are topographically different may be very large. If most reinforcer classes are enormously large (e.g., things that are "good") the question of topography vs function may be a moot point with regards to the present study.

Thus, enhanced persistence was found consistently across both

phases. Yet, enhanced persistence was not found with all subjects. As with the bird data, the positive correlation between the p-value differences and the level of contrast may help to clarify why the effect was found in some children but not others. Using this same logic described in Experiment 1, the lack of contrast appears to indicate that the lights did not function as contextual cues. That is, suppose that the free reinforcers were not associated with either contextual cue. Each contextual cue (colored light) may have only signalled the rate of reinforcement during that color, which was equal in either color. That is, the contextual cue associated with the added reinforcers, may not have functioned to signal those extra reinforcers. The shared features across all sources of reinforcement may have been those which defined the laboratory room (or the University). If the added reinforcers were not associated with either colored light, then the rate of reinforcement in each color would be the same. Given that this rate would be compared to the same overall average, as signalled by the experimental room, the evocative strength of each light context would be the same. Thus, no differences in response rate (e.g., contrast) or resistance between the two contexts would be expected, as was sometimes found. As in Experiment 1, it appears that there were individual differences in how the stimuli functioned or were perceived.

As with the bird study, there may be ways to manipulate the environment in order to make the extra reinforcers more reliably associated with one contextual cue or the other. One way to

accomplish this may be to deliver the free reinforcers while the response was ongoing. Another way would be to make the context cues more salient (e.g., have the contextual cues be different color room lights or different audio stimulation). It may be that the verbal cue, which was included in order to have the client "attend" to the contextual cue, was ineffective (e.g., children have a history of not listening to adults). In fact, outside the laboratory, context cues are probably very salient (e.g., church vs. school), again suggesting that the enhanced persistence effect might be greater in the "real world".

Finally, the preparation arranged in Experiment 2 may appear different from that of Experiment 1. If so, one may question whether the similarity of effects between the two studies are reflecting the same basic processes. Thus, it may be useful to discuss the functional similarities between the two procedures. In both experiments, a target response was identified and reinforced (keypecking vs. decreasing EMG levels). Alternative reinforcement was then provided from another source in both preparations (food in Experiment 2, added points or candy in Experiment 1). Although the alternative source in Experiment 1 was contingent on a second response and the alternative source in Experiment 2 was non-contingent upon any response, recall that it was found that added reinforcers increases resistance regardless of whether these reinforcers are "free" or contingent upon a second response (Nevin et al., 1990). Finally, a stimulus, which can be called contextual, was present during the delivery of reinforcement obtained from the

target as well as that from the alternative source. In Experiment 1, side lights defined the rich vs. lean context. In Experiment 2, colored lights also defined the richer vs. leaner context (i.e., whether contingent only or contingent plus non-contingent points would be available). Thus, while the two experimental procedures are topographically different, the functional relations are similar.

CHAPTER IX

GENERAL DISCUSSION

In examining the results from both Experiments 1 and 2, we see some similarities and some apparent differences between the results from birds and humans. In both procedures, though, it appears that enhanced persistence of a target response can result from an alternative reinforcement source. In addition to the experiments reported here, several other studies using a variety of techniques and methods, have all obtained similar results. In the Nevin et al. (1990) study, two different preparations were used with pigeons as subjects. In the Mace et al. study, similar results were obtained with two retarded adults sorting utensils. In Experiment 1 of the present research, a conditional discrimination task using pigeons as subjects was arranged. In the second experiment, children learned to "relax" using biofeedback. In all preparations, alternative reinforcement led to enhanced persistence of a target response. Thus, such convergence of findings and similarities in the data all seem to point to a general phenomenon regarding alternative reinforcement and resistance.

One discrepancy, however, between the bird and human data was the size of the effects. A possible reason for the small size of the effects found with the human subjects were discussed in the Discussion of Experiment 2. Overall, there was more variability in

the human data than the bird data. A second notable dissimilarity concerns contrast. While contrast was consistently found in most birds, it was not a reliable effect with the humans. While contrast was seen in some human subjects, it could not be determined if the contrast was reliable because the humans were not examined over many sessions, as with the birds. Additionally, as was discussed earlier, the increased variability within the human data was likely due to the increased lack of control over many aspects of the subject's past and present environment. This lack of control would make it less likely that the kind of contextual control necessary to find enhanced persistence would occur. This lack of control also would be responsible for the lack of a reliable finding regarding contrast.

An important similarity between the two sets of data was the positive correlation found in both studies between the level of contrast and the size of the p difference value. That is, when contrast was not found (suggesting that contextual control had not occurred), enhanced persistence was also not likely to be found.

In sum, the differences between the two sets of data may be more due to spurious factors than to differences in the processes which produced the effect. The similarities in the data (enhanced persistence in the rich context, the p-value/contrast correlations) suggest that the effects found in both experiments were due to similar processes.

The novel contributions of Experiments 1 and 2 are twofold. First, Experiment 1 provided evidence that contextual cues are responsible for enhanced persistense, not the TS^D. Contrast, though, is an effect of the evocative strength of the TS^D, which is opposite to that of the contextual cue with respect to alternative reinforcement. In addition, how evocative a stimulus becomes depends on the rate signalled by the stimulus relative to the rate signalled by the surrounding context. Experiment 2, supported the contention that the excitatory effect evoked by the contextual cue is general to reinforcement type, which leads to something akin to a general arousal level.

Theoretically and practically, what implications do the results from these two experiments have? First, as suggested in the Introduction, this line of research has implications for how we use the term "response strength." In the past, it was thought that rate and persistence were functions of the same variables and would co-vary. As a result, predictions about persistence would be based upon what was known about rate. The terms, rate and response strength, soon became interchangeable. Research on the partial reinforcement effect suggested that rate of reinforcement affects rate and persistence differentially. This proved not to be the case (in fact, the rate of reinforcement affects both rate and persistence similarly), yet the present line of research has identified a variable which appears to affect rate but not persistence. That is, the evocative effects of contextual cues appear not to have an effect on rate, but leads to an

enhancement or depression of persistence. Thus, if one were interested in altering rate, the focus should be on the operant contingency; conversely if one were interested in altering persistence, in addition to the operant contingency, one should also recognize the impact of the pertinent Pavlovian contingency and the evocative effects of the surrounding contextual cues.

It makes intuitive sense that rate and persistence would be separate properties of behavior. For example, one can imagine having a behavior of a low rate but which is very persistent or a behavior occur at a high rate which does not persist very long. Often, psychologists are interested in either a behavior's rate or its persistence, but not always both. Also, there may be times when questions of persistence are important, regardless of rate. For example, therapists wish to have their clients "hooked into" therapy so that when therapy becomes more difficult, clients will persist in "therapy behavior" (e.g., coming to the sessions, talking). Also, therapists are very interested in getting clients to persist in the positive gains they make in therapy, especially in situations where these behaviors are not supported at first. Finally, there may be instances of behavior where questions of rate may not be appropriate, but issues of persistence are clear (e.g., when we speak of more fluid responses, such as "relaxation"). Thus, intuitively it seems that persistence is an important property of behavior in its own right. The present line of research supports this notion.

The persistence of a behavior appears to be, in part, a result of a Pavlovian process regarding the "context" in which it occurs. The present research in conjunction with others (Nevin, 1990; Nevin et al., 1990) may help to clarify what is meant by the facilitation by the "context". As stated, the present research has shown that the evocative effect of a contextual cue may faciliatate persistence. How evocative a contextual cue becomes is relative to the overall context. That is, the evocative strength of a stimulus depends on the rate of reinforcement that the cue signals relative to the rate that the context signals. The evocative strength of a TS^D is also dependent upon the relation of the rate of reinforcement signalled by the TS^D to the contextual cues. The evocative strength of the TS^D, when an alternative reinforcement source is given, results in the decrease in rate.

The data reported here also alerts us that context is not solely a function of present environmental relations, but past relations as well. In both Experiment 1 and 2, individual differences in how the birds and humans "perceived" the stimuli and context were cited. That is, presumably as a result of a given environmental history, such stimuli were less likely to function as contextual. This was evidenced by the lack of contrast found.

It may be a useful exercise to speculate, first on some everyday examples of where additional reinforcement may influence behavior and, second, on potential applications if it is found that these results are truly general. First, there may be many situations where

changes in behavior are seen given the context. Often such changes are attributed to motivational factors. For example, a parent may be confused about his/her son's lack of motivation at school, but his increased activity level at home. Such changes in motivational levels between contexts in the same behavior often leave observers perplexed. An example of this effect may be when one talks about the "home team advantage" in sports. Perhaps part of this advantage is that "home" is usually a context rich in reinforcement as compared with "away" stadiums. Perhaps a team is more likely to persist at home than when away. Of course the opposite may also occur. That is, for a team that often gets "booed" at home, an away stadium may be richer in reinforcement as compared to the home stadium. Perhaps then the team may persist longer in games played on the road (which may make the fans "angry" leading to more "booing"). A second example of where the effect described here may be operating concerns the tendency for people to place personal items on their desks at work (e.g., pictures of children and spouse, flowers). The effect of this may be to bring contextual cues of the home life, which may be richer in reinforcment than the work place, to work with them. Such cues may lead to an enhancement of behavior which may be described as "boosting" one's feelings or making one "feel good". More generally, this may be related to the term "morale" among a group of individuals. This term may, in part, be referring to the behavior effects due to the richness or leaness of avaiable reinforcers within the situation. In fact, it has been shown that

satisfaction at work (which is likely to be due, in part, to current reinforcers), is positively correlated with job performance (Vroom,1964).

A second area of speculation concerns applied educational and psychotherapeutic implications of the effect. Such speculating may lead to more applied research based on the present findings. For example, in teaching social skills, it may be beneficial to teach this behavior in an environment rich in reinforcement. One way to arrange such an environment is to have the client perform tasks he or she already knows how to do along with the behavior he or she is learning to perform. This would be analogous to having a target behavior and an alternative source of reinforcement available from an already mastered second response. As another example, part of therapy may be to teach the client to make his or her home environment richer in reinforcement. An example of such a clinical technique may be Lewinsohn's pleasant events scheduling (Lewinsohn & Arconad, 1981), where a therapist teaches a client to schedule reinforcing events into their daily lives in order to increase the likelihood of positive target behaviors. The effect of this technique on target behavior may lead to a decrease in rate but an increase in persistence.

A second application may be to biofeedback. Perhaps one way to make the gains obtained with this technique persist longer is to arrange two contexts. In the presence of one contextual cue (a cue which can be used by the client outside of therapy, e.g., the word

"relax"), a target response can be trained (e.g., decreasing EMG levels) simultaneously or alternatively with a second response (decreasing finger temperature) from which alternative reinforcment could be obtained. This preparation can be alternated with the training of the target response in the presence of a second contextual cue. During this context, no alternative reinforcement would be available. The contextual cue associated with the added reinforcement should become evocative because it signalled a greater rate of reinforcement. After treatment is terminated, if the contextual cue associated with the added reinforcement is present outside of therapy, the persistence of the relaxation response may be enhanced.

Finally, it might be interesting to analyze parts of psychotherapy in terms of the ideas described here. For example, it may be that the notions introduced here may help understand the seemingly intuitive importance of the notion of unconditional positive regard in therapy (Rogers, 1961). This notion involves the therapist becoming "warm, genuine, and empathetic," giving the client unconditional positive regard. This, it is believed, is powerful enough to get the client to alter behavior and begin to act more adaptively. Many therapists would agree that such a "safe" environment is beneficial for the client. Unconditional positive regard is seen by many as a form of social reinforcement (e.g., behavior is accepted, not punished). Some therapists might argue that such "free" reinforcement is not beneficial as it leads to a drop in response rate (clients may work less in therapy). Yet providing a

situation rich with reinforcment, through positive regard, may not only allow the client to behave in ways that were punished in the past, but could also produce more resistant positive gains than if therapy were lean in positive regard. Also, clients may be more likely to persist in therapy when things get "tougher," as when more painful material begins to be the focus.

The present line of research may also suggest that early in therapy, before a client's behavior changes, a situation rich in reinforcement may lead to more persistence of the behavior that the client is wishing to change. Thus, while unconditional positive regard may be beneficial in several respects, a therapist should be aware of the effects of this therapeutic stance at different points in therapy.

In sum, a therapist must remain aware that a variable (such as "free" reinforcement) which can have a weakening effect on behavior (leads to a decrease in rate) can actually lead to an enhancement of a behavior's persistence.

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APPENDIX A. FIGURES

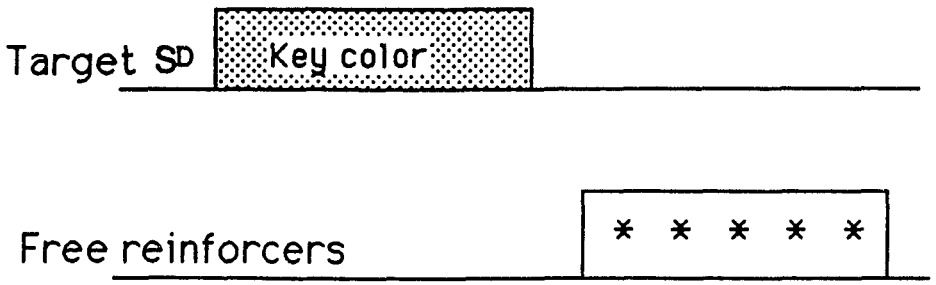


Figure 1 The target SD functions as a CS. It may become excitatory through its pairing with the free reinforcers.

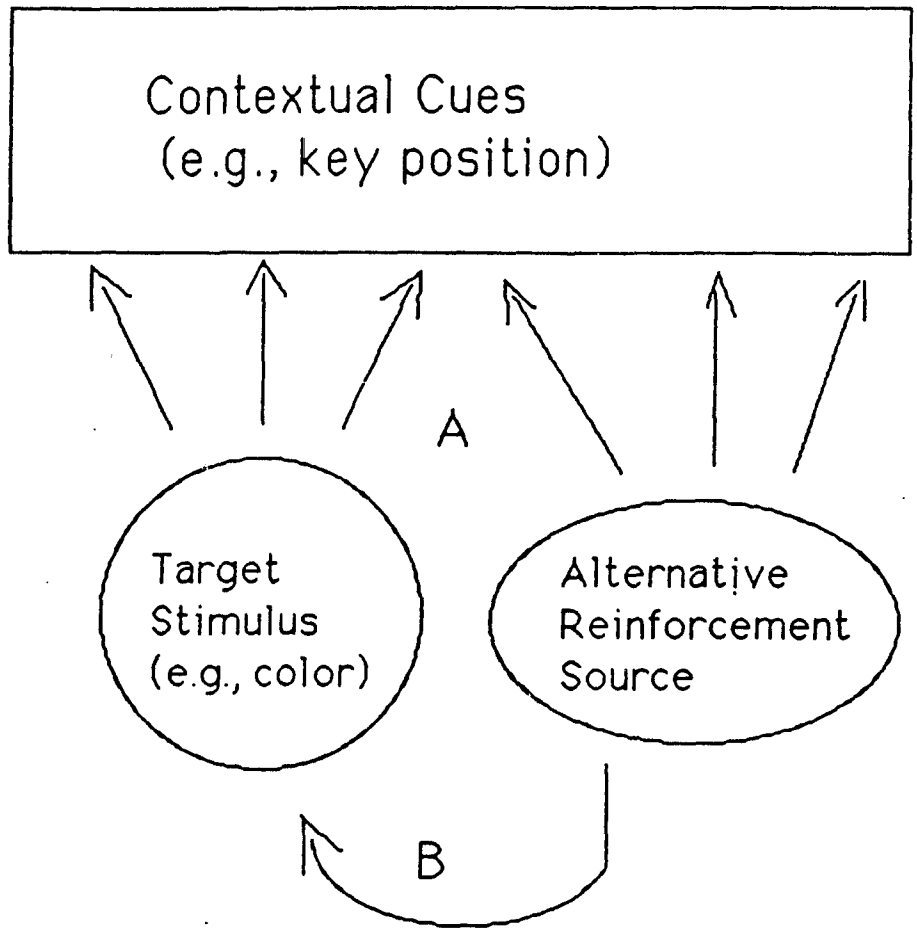


Figure 2 Conditioning may occur to the contextual cues (A) or it may occur to the target stimulus (B).

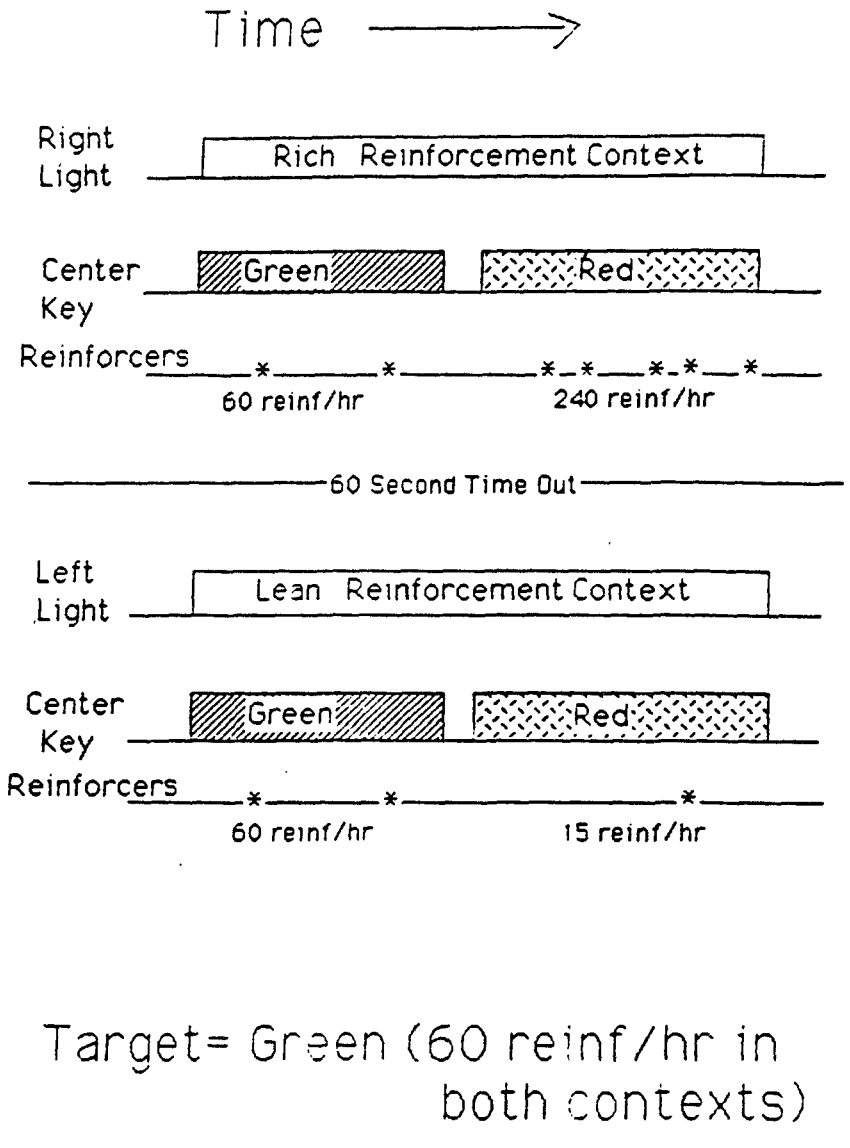


Figure 3A The procedure in Experiment 1, Forward Phase.

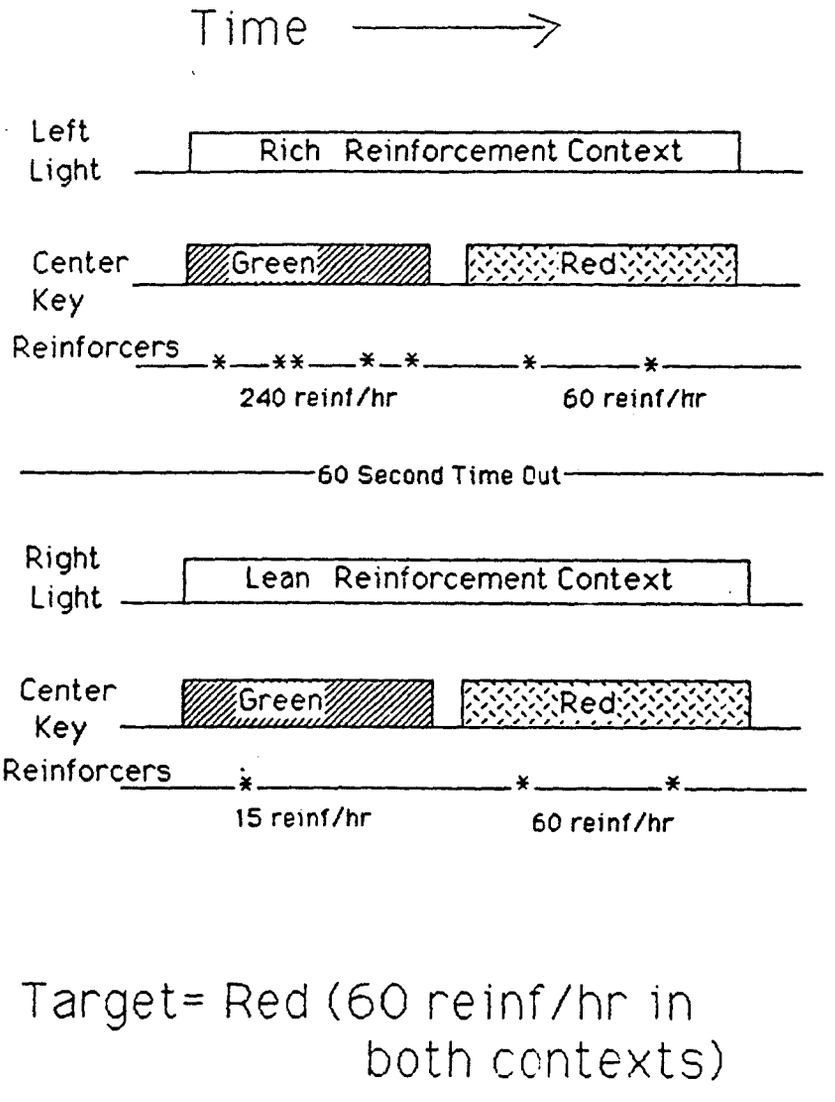


Figure 3B The procedure in Experiment 1, Backward Phase.

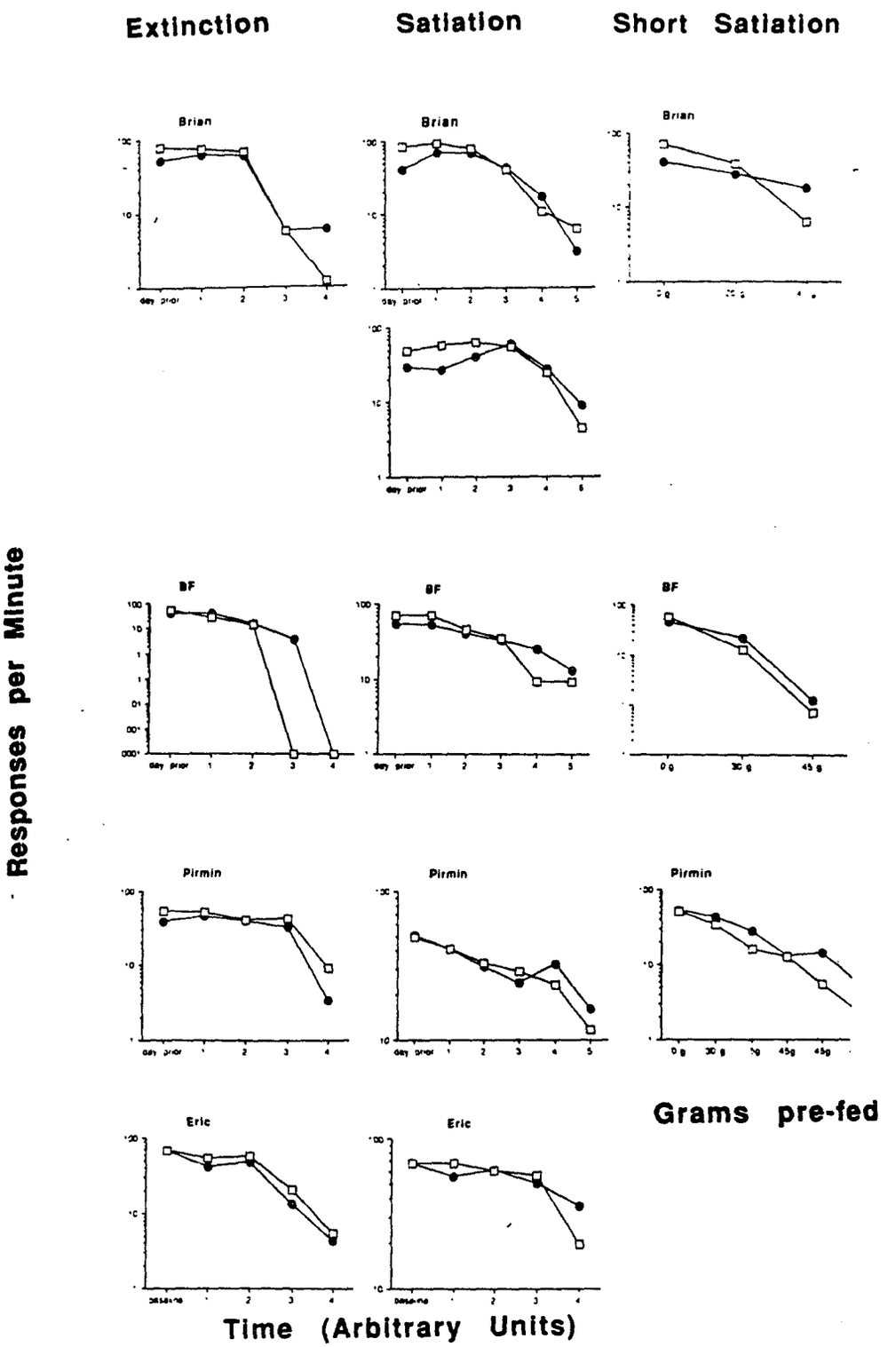


Figure 4A Responses per minute during resistance tests from the forward phase.

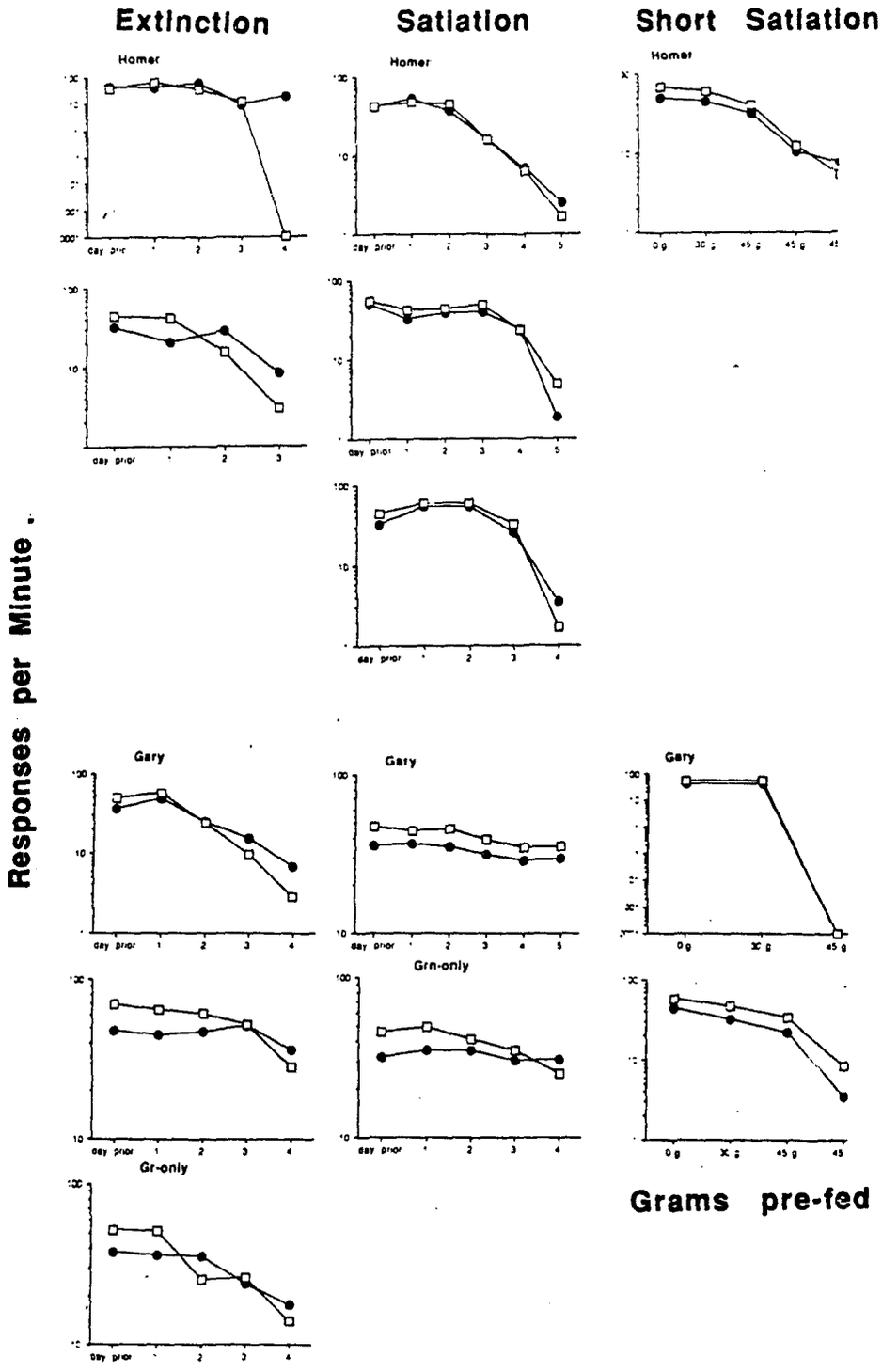


Figure 4A Data obtained from the forward phase.

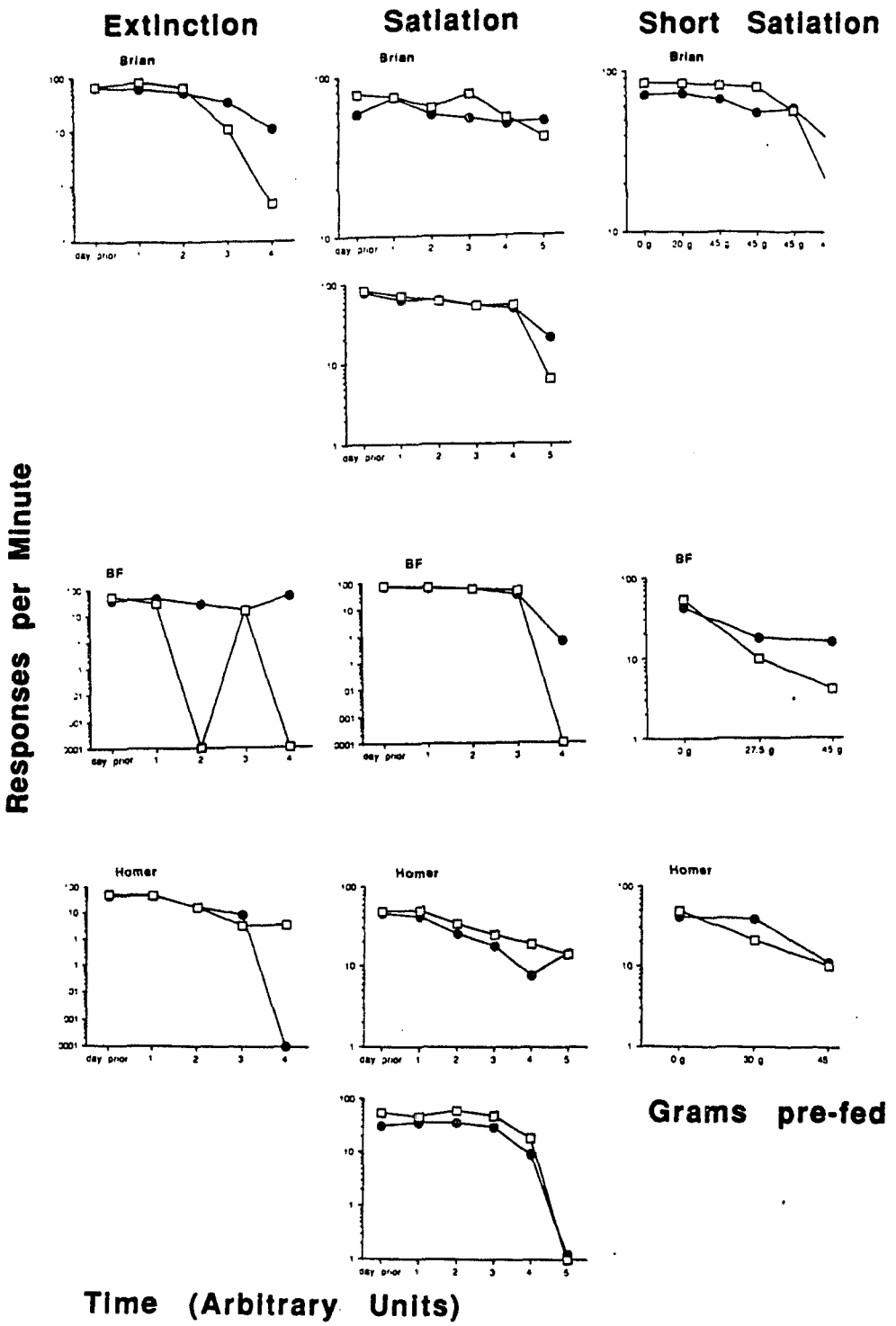


Figure 4B Responses per minute during resistance tests from the backward phase.

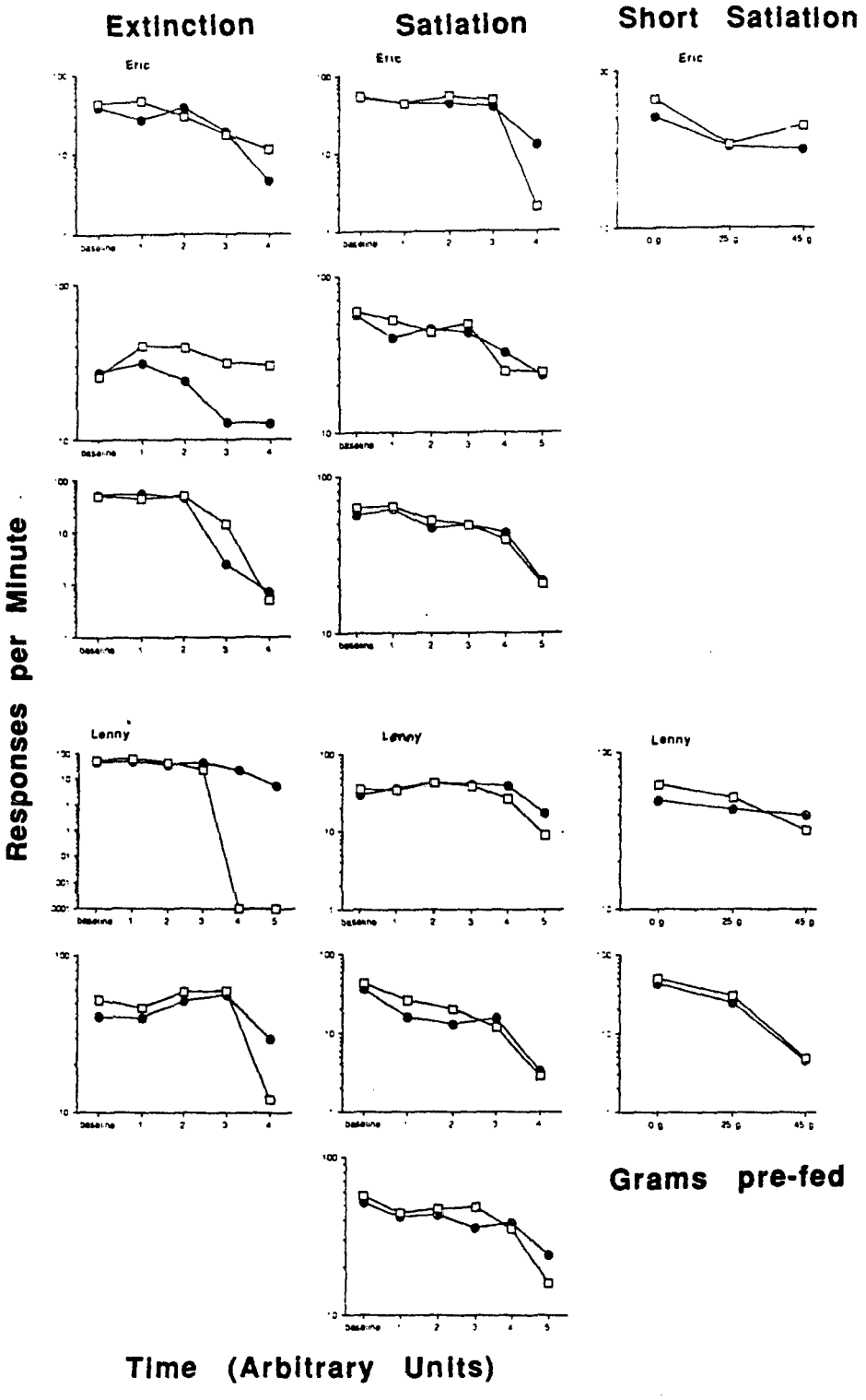


Figure 4B Data obtained from the backward phase.

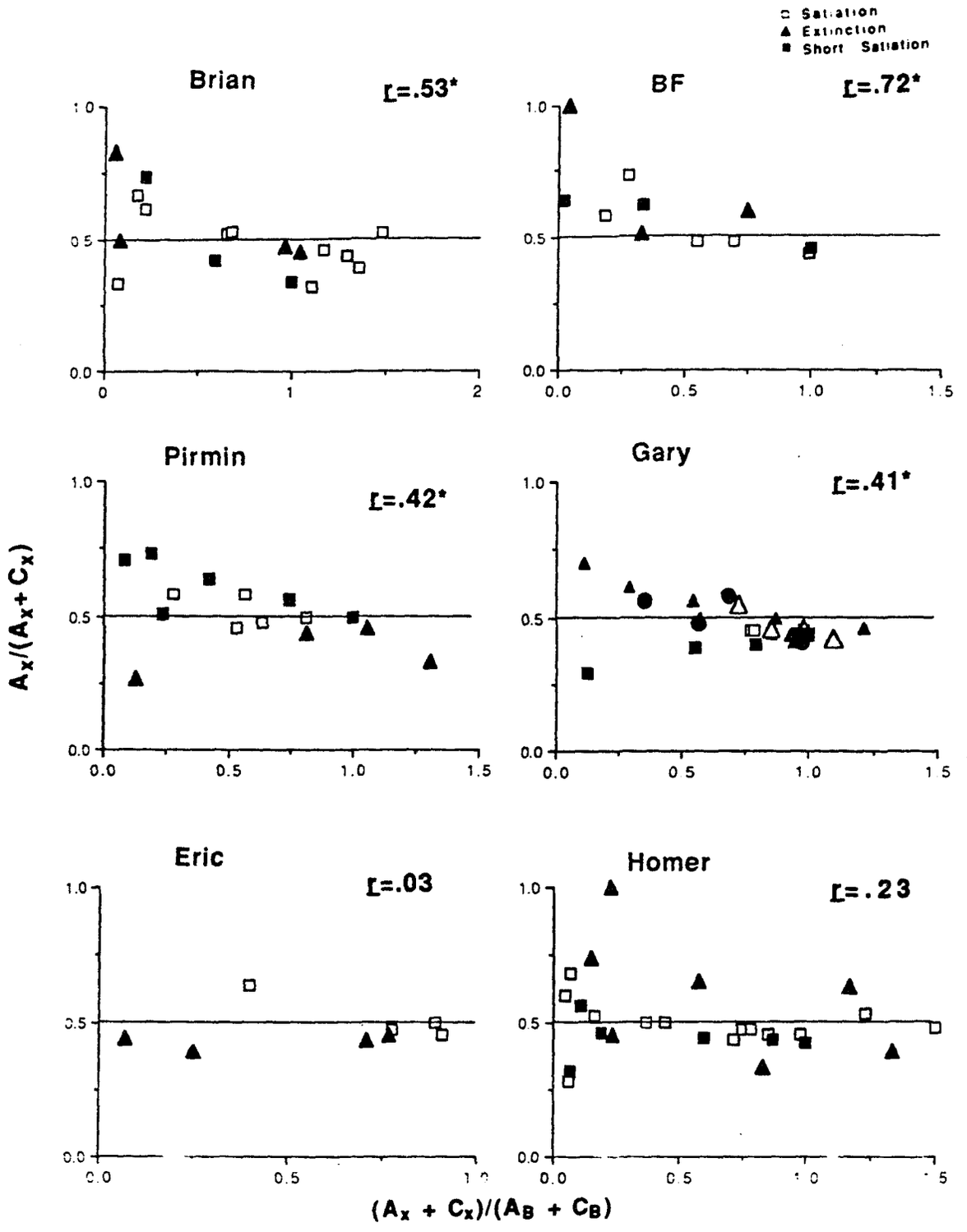


Figure 5A Relative disruption as a function of overall disruption in the forward phase.

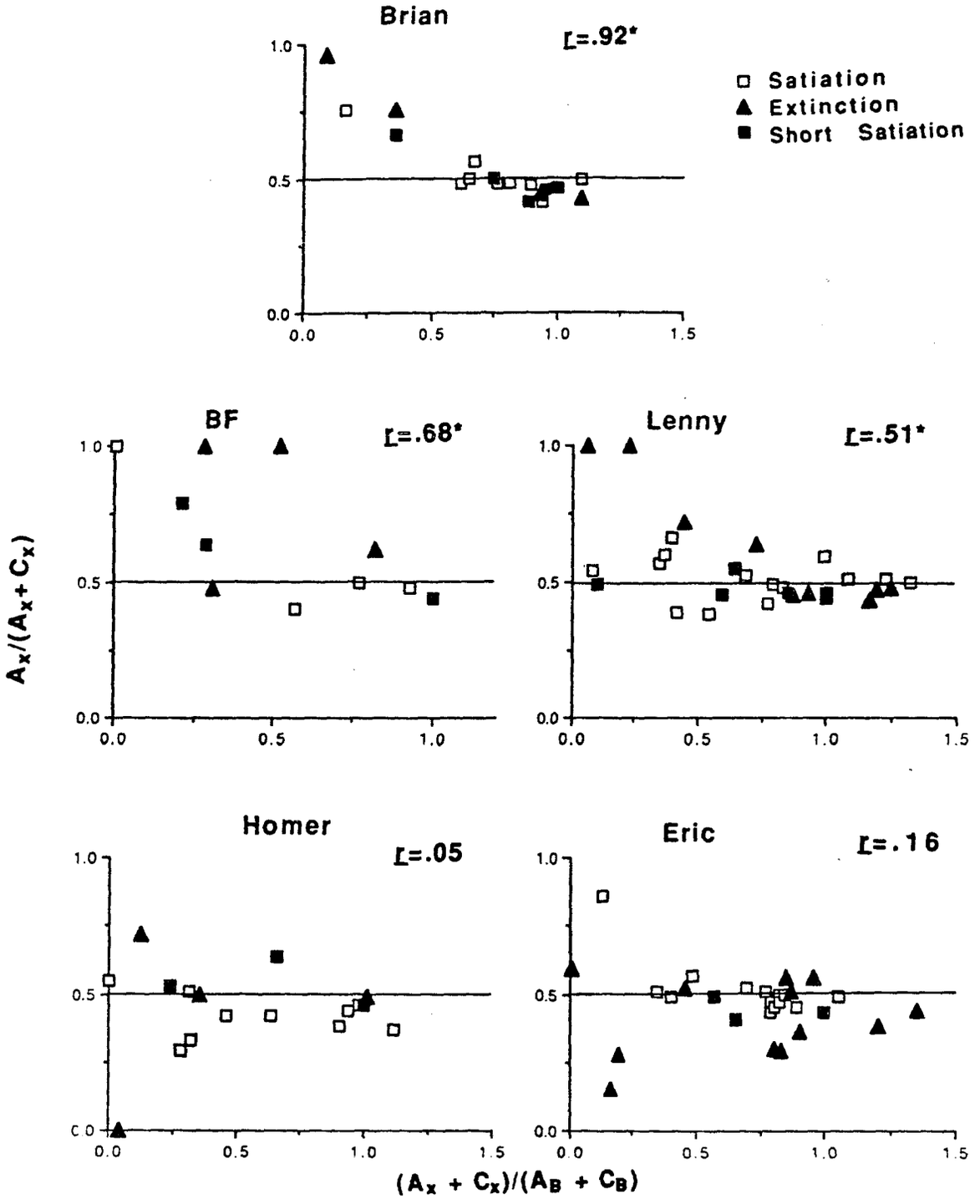


Figure 5B Relative disruption as a function of overall disruption in the backward phase.

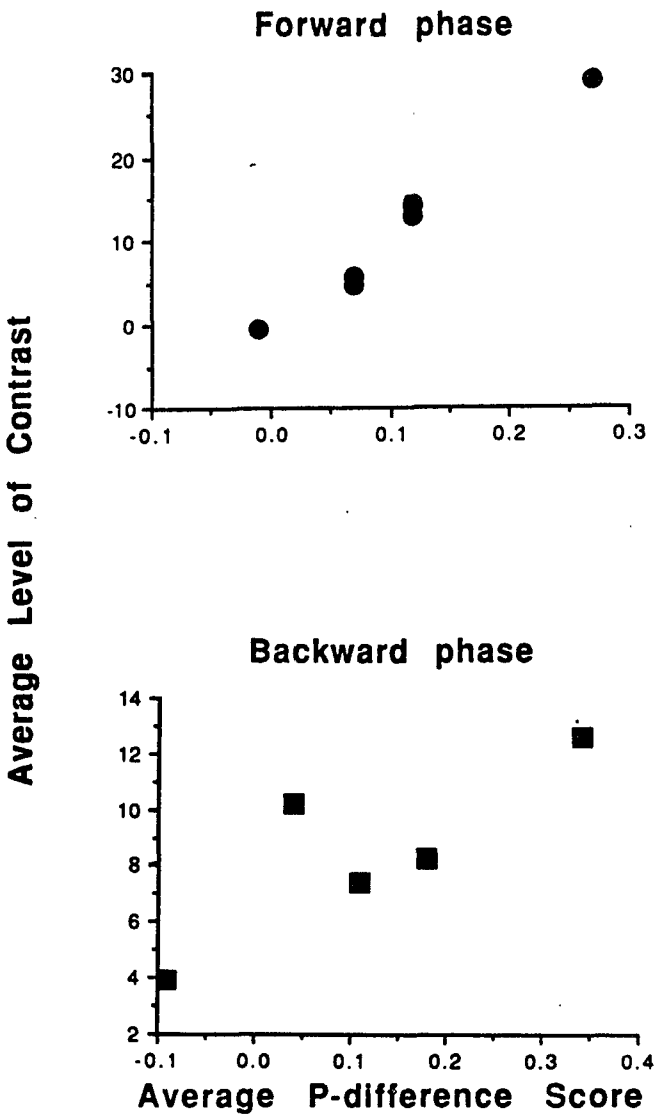
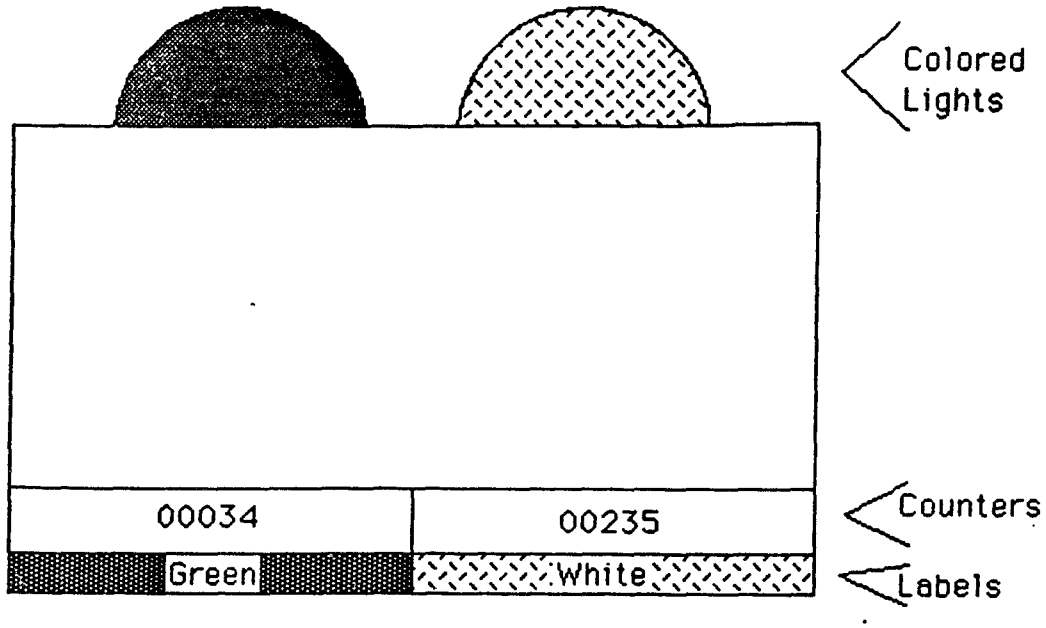


Figure 6 Average level of contrast versus average p-difference value obtained in both phases.



Apparatus

Figure 7 Apparatus used in Experiment 2.

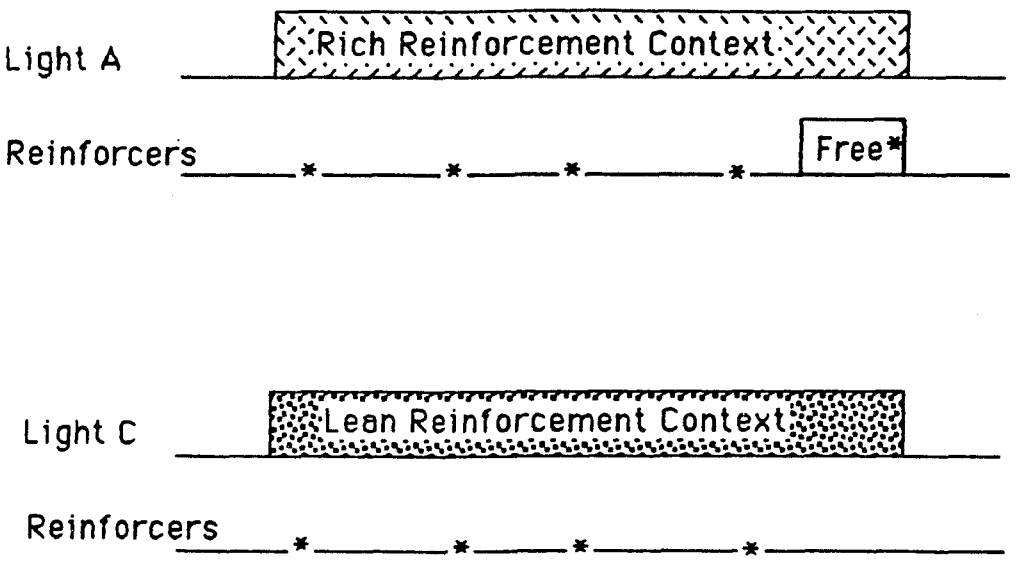


Figure 8 Procedure of Experiment 2

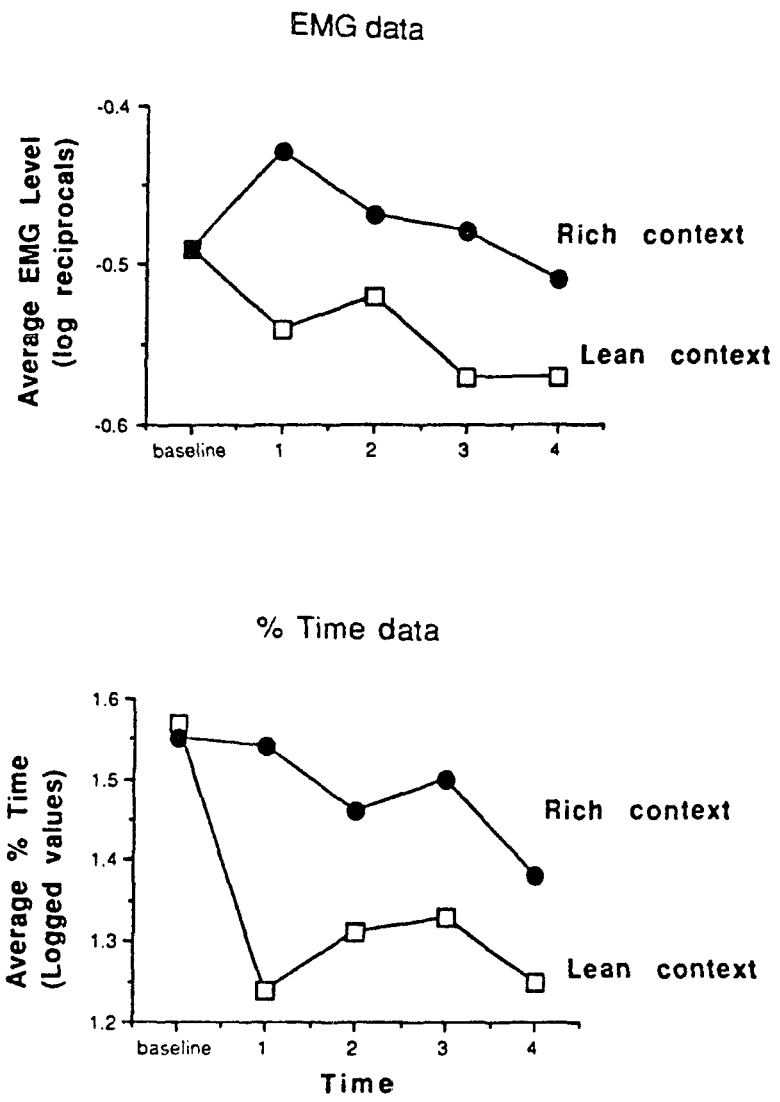


Figure 9A Average data obtained from Phase-same.

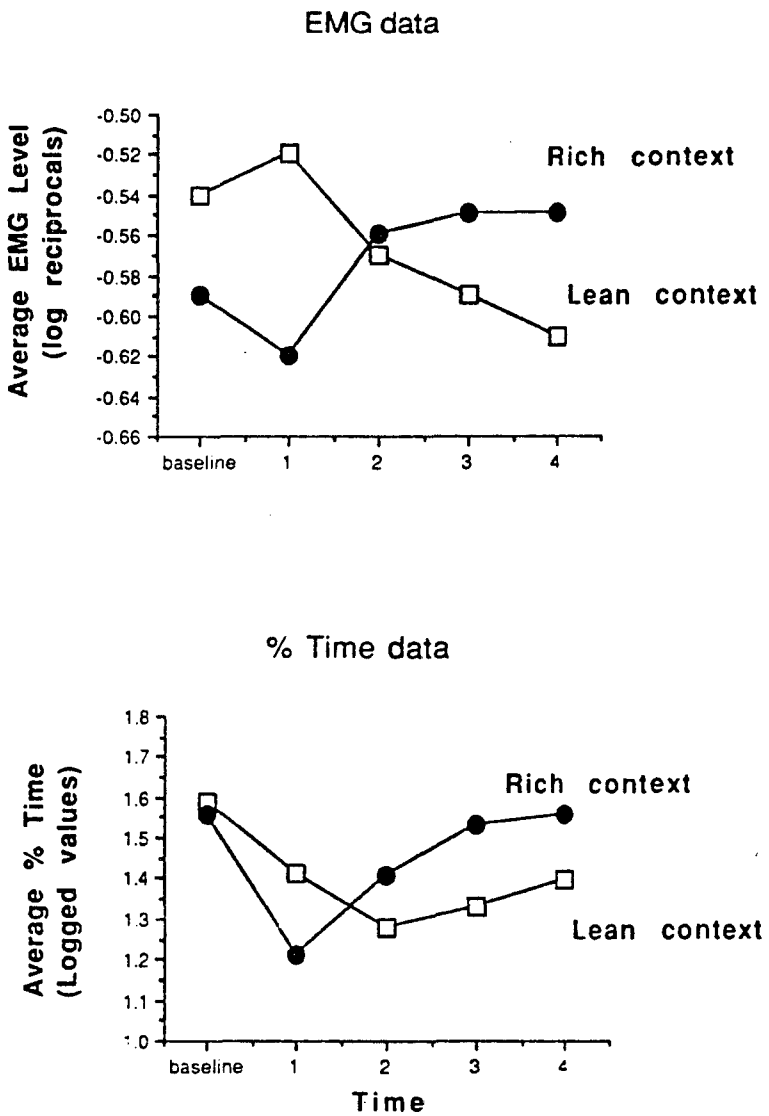


Figure 9B Average data obtained from Phase-different.

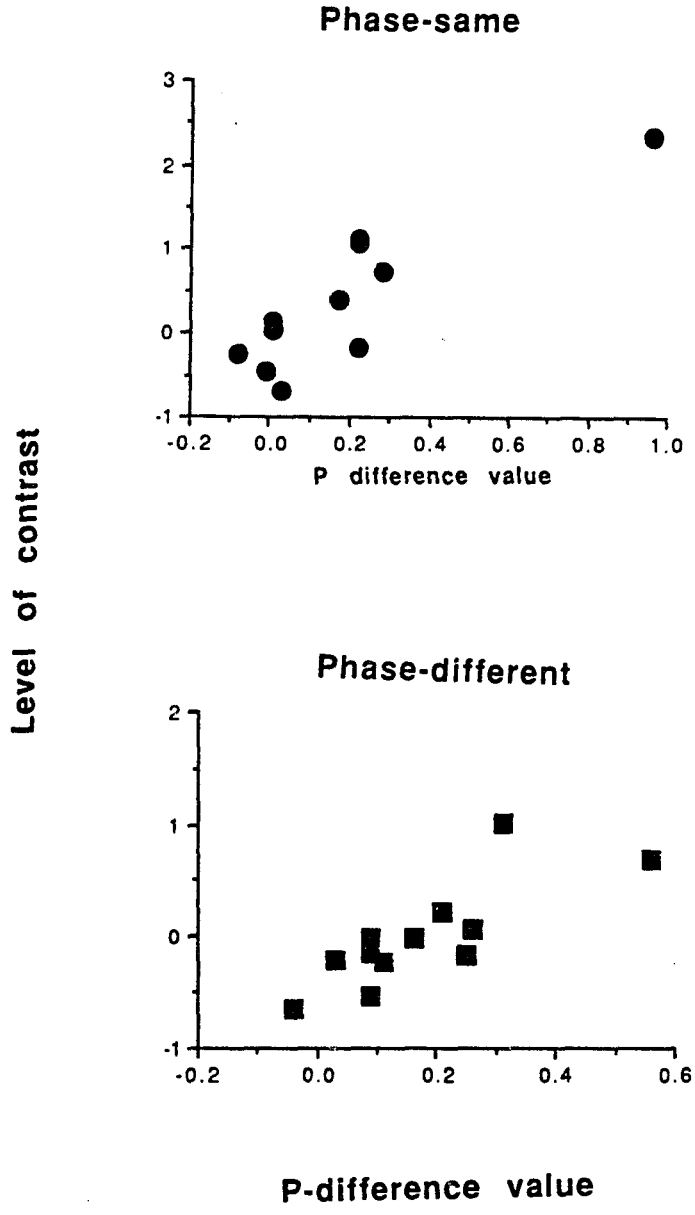


Figure 10 Level of contrast versus p-difference values obtained in both phases.

APPENDIX B. RELATIVE RATES OF REINFORCEMENT

Relative Rates of Reinforcement

The effect of enhanced persistence due to alternative rates of reinforcement can also be described by Herrnstein's equation, briefly described above, which emphasizes relative rates of reinforcement as the determiner of persistence. Herrnstein's equation (1970) can also be expressed as follows:

$$B = \frac{kR}{R + R_a + R_e}$$

where B is the rate of the target response, R is the obtained rate of the reinforcement for the target response, R_a is the obtained rate of the experimentally arranged alternative reinforcers in the presence of the stimulus where B and R occur, R_e is the rate of extraneous, unprogrammed reinforcers obtained during the stimulus and k is a constant. The denominator specifies the total rate of reinforcement during the component stimulus. This equation predicts that an alternative source of reinforcement will decrease response rate given that an alternative source (R_a) increases the denominator of the equation. The larger R_a is, with R remaining constant, the larger the denominator and thus the smaller B is. Herrnstein's equation can

also predict a slower drop in rate (i.e., increased resistance to change) given an alternative source of reinforcement as extinction or satiation changes the values of R, R_a and R_e. It may be assumed that as extinction or satiation progresses, the values of R and R_a in baseline become degraded by some function in proportion to their baseline values. In the equation, decreases in R and R_a is mathematically equivalent to increasing R_e (the value of extraneous reinforcers; e.g., preening) while R and R_a remain constant. Thus, it can be assumed that as extinction or satiation progresses the only value changing will be R_e, which will become larger by some value as time goes on. In the situation with a greater alternative source of reinforcement, the denominator will be greater given the greater R_a value. Thus, increases in R_e will lead to a smaller proportional increase in the larger denominator (due to the larger R_a) than in the smaller denominator (due to a smaller R_a). This smaller proportion increase will result in a smaller change in rate as time goes on. Thus the equation predicts that as R_e increases, the response in the situation with the greater alternative reinforcement will have a shallower slope in extinction or satiation.

For example, take two situations where there are equal rates of reinforcement (R_1=1, R_2=1) but differing amounts of alternative reinforcement (R_{a1}=1, R_{a2}=0). When R_e=0, as in baseline, the rate of responding in the two situations will be as follows:

Situation one

$$B=.5=\frac{1}{1+1+0}$$

Situation two

$$B=1=\frac{1}{1+0+0}$$

As R_e increases, however, the rate will drop but at different rates for the two situations. Thus, if $R_e=2$ (as it may be in extinction), then the rate of responding for the two situations will be as follows:

Situation one

$$B=.25=\frac{1}{1+1+2}$$

Situation two

$$B=.33=\frac{1}{1+0+2}$$

As you can see, there is a smaller proportional drop from baseline to extinction in situation one (from .5 to .25, a 50% drop) than situation two (from 1 to .33, a 66% drop). As extinction progresses, the two rates become much more similar than they were in baseline. Thus, the relative change from baseline differs depending upon the amount of alternative reinforcement.

As stated in the text, this relative rate account may not be fundamentally different from the Pavlovian one. That is, the denominator in the equation may be formally expressing the Pavlovain relationship. Herrnstein's equation, however, is not consistent with all aspects of the above described data but there have been modifications of this equation which better fit all aspects

of the data (see Nevin, Tota, Torquato & Shull, 1990; Burgess & Weardon, 1986).

APPENDIX C. ALTERNATIVE ACCOUNTS

Alternative accounts: Melioration and misattribution

Although the possibility of a Pavlovian process, as formalized by Herrnstein's denominator, facilitating the persistence of responding is intriguing and has broad implications for basic and applied issues, there may be some less interesting alternative accounts for the data. Such interpretations can clearly account for the data when a concurrent procedure (alternative reinforcement presented concurrently with the target reinforcement) is used, as was most often the case in previous reports. Before it can be concluded that these effects represent a fundamental property concerning reinforcement and resistance to change, such interpretations need to be ruled out. The multiple schedule paradigm in Experiment 1 will be able to evaluate whether these alternative account are viable.

One alternative hypothesis concerns the local rate of reinforcement or the amount of reinforcement obtained given the amount of time spent engaged in the target response. When there is no alternative source of reinforcement, the pigeon can spend 100% of the time engaged in the target response. In the situation with the alternative reinforcement, the pigeon now spends less time on the target response given that the additional source requires an allocation of part of his time in the session. That is, the alternative

source draws time away from the target response. During the time engaged in other behavior, the VI clock for the target response is still running and upon return to the target response, the pigeon may need to spend less time responding. Thus, given the nature of the VI schedule, the pigeon still collects all the reinforcement but in a less amount of time spent engaged in the response. For example, if the subject receives 60 reinforcements in 60 minutes his rate of reinforcement is 60 per hour. But if he recieves the same 60 reinforcers in 30 minutes of time spent on the target response, then his local rate of reinforcement for this response is 120 per hour. This greater local rate of reinforcment in the situation with alternative reinforcement may be what is producing the greater resistance to change.

A second alternative hypothesis concerns "misattribution" or superstition. For example, when a pigeon pecks the key where he receives alternative reinforcement he may then "forget" which key produced food. Misattributing some of the additional reinforcers to the target response may lead to the observed increased resistance to change.

One earlier study (Nevin, 1984) did not utilize a concurrent procedure but separated the alternative and target sources of reinforcement in time. Nevin arranged conditions in a three key pigeon chamber where one of the three keys randomly would be lit for one minute. Each key was of a different color but all had a VI 120-s schedule associated with them. After the one minute elapsed,

the key in this first component would change color and a different VT or EXT schedule was active on that same key. On the left key a VT 24-s schedule was in effect in the second component, on the center a VT 120-s schedule and on the right, no additional reinforcers were given during the second component. Thus, the second component was perfectly correlated with key location and color of the first component.

It is assumed that in this procedure the subject can spend 100% of the time on the target response, as the alternative source is delivered when the target response can not occur. Thus, the additional reinforcers will not draw time away from the target. Separation in time also makes it less likely that additional reinforcement will be "misattributed". Nevin found that there was greater resistance to change to the first component target response when this stimulus was followed by a greater amount of alternative reinforcement during the second component.

This study makes it more difficult for melioration or misattribution to account for the data. However, it could still be argued that subjects "misattributed" the transistion between components one and two to a key peck during the last few seconds of component one. Secondly, the amount of time (local rates) during the three first components may not have been equal. It is possible that subject's during the components followed by the VT's may spend part of their time "looking for" or "anticipating" the key color change.

Experiment 1 of the present proposal also separated the target

and alternative sources of reinforcement in a way that makes melioration and misattribution even less plausible than the Nevin (1984) study. In Experiment 1 the transition between the two components was separated by a 5 second time out which reduces possible superstitious reinforcement of the keypeck before the transistion. Phase 2 had the additional reinforcement presented **before** the target. Thus, time in the target component would not be spent by the subjects "looking for" the additional reinforcers.

If the general finding that additional reinforcement enhances the persistence of responding is due to melioration (i.e., local rates of reinforcement) or misattribution, then a paradigm which equates local rates and minimizes the possibility of misattribution, should not produce the basic findings. However, if the enhanced persistence found in previous reports is a more fundamental effect, then separating the alternative and target sources of reinforcement should still produce these effects.

APPENDIX D. TABLES

Forward phase

Subject	Rich context Target	Lean context Target	Alternative source rich	Alternative source lean
Brian	38.32	78.60	73.90	12.92
Homer	42.27	43.04	68.79	25.92
BF	50.89	65.32	89.96	7.62
Gary	30.12	49.36	39.32	9.14
Pirmin	44.06	51.88	46.91	17.83
Eric	60.68	54.85	75.69	24.18

Backward phase

Subject	Rich context Target	Lean context Target	Alternative source rich	Alternative source lean
Brian	67.84	81.13	85.53	28.06
Lenny	26.74	34.33	32.02	19.03
BF	54.25	59.10	73.87	32.85
Homer	35.23	36.32	53.01	19.02
Eric	56.23	57.40	61.92	24.17

Table 1 Average responses per minute during each component (target vs. alternative) in both contexts (rich vs. lean), obtained during the five days of baseline training prior to the first resistance test.

Subjects	P-difference value
Brian	
Extinction	.13
Satiation	.33
Satiation	.35
Short Satiation	.28
BF	
Extinction	.10
Satiation	.16
Short Satiation	.10
Homer	
Extinction	.13
Extinction	.26
Satiation	.01
Satiation	-.06
Satiation	.16
Short Satiation	.03
Eric	
Extinction	-.08
Satiation	.05
Gary	
Extinction	.26
Extinction	.17
Extinction	.21
Satiation	.06
Satiation	.26
Short Satiation	-.01
Short Satiation	-.01
Pirmin	
Extinction	.06
Satiation	.05
Short Satiation	.11

Table 2A P-difference values from the forward phase.

Subjects	P-difference value
Brian	
Extinction	.14
Satiation	.06
Short Satiation	.12
BF	
Extinction	.77
Satiation	-.02
Short Satiation	.28
Homer	
Extinction	.03
Satiation	-.11
Satiation	.04
Short Satiation	.22
Lenny	
Extinction	.27
Extinction	.31
Satiation	.35
Satiation	.07
Satiation	.02
Short Satiation	.22
Short Satiation	-.01
Eric	
Extinction	-.02
Extinction	-.71
Extinction	-.08
Satiation	.02
Satiation	.08
Satiation	.05
Short Satiation	.01

Table 2B P-difference values from the backward phase.

EMG LEVELS

Source		df	Mean Square	F-ratio
A	.107	1	.107	26. 630*
AxS	.004	11		
B	.059	4	.0148	.779
AxB	.019	44		
AxB	.036	4	.0089	1.630
AxBxS	.005	44		

% TIME DATA

Source		df	Mean Square	F-ratio
A	.112	1	.112	7.540*
AxS	.163	11		
B	.184	4	.0460	.867
BxS	2.340	44		
AxB	.077	4	.0193	1.990
AxBxS	.427	44		

Table 3A Anova table for the data obtained in Phase-same. Those values starred are significant at or below .05.

EMG LEVELS

Source	Source	df	Mean Square	F-ratio
A	.002	1	.002	1.67
AxS	.012	10		
B	.004	4	.001	.10
BxS	.399	40		
AxB	.107	4	.027	4.92*
AxBxS	.217	40		

% TIME DATA

Source	Source	df	Mean Square	F-ratio
A	.001	1	.001	.190
AxS	.053	10		
B	.048	4	.012	.490
BxS	.979	40		
AxB	.227	4	.057	4.077*
AxBxS	.564	40		

Table 3B Anova table from the data obtained obtained in Phase- different. Those values starred are significant at or below the .05 level.

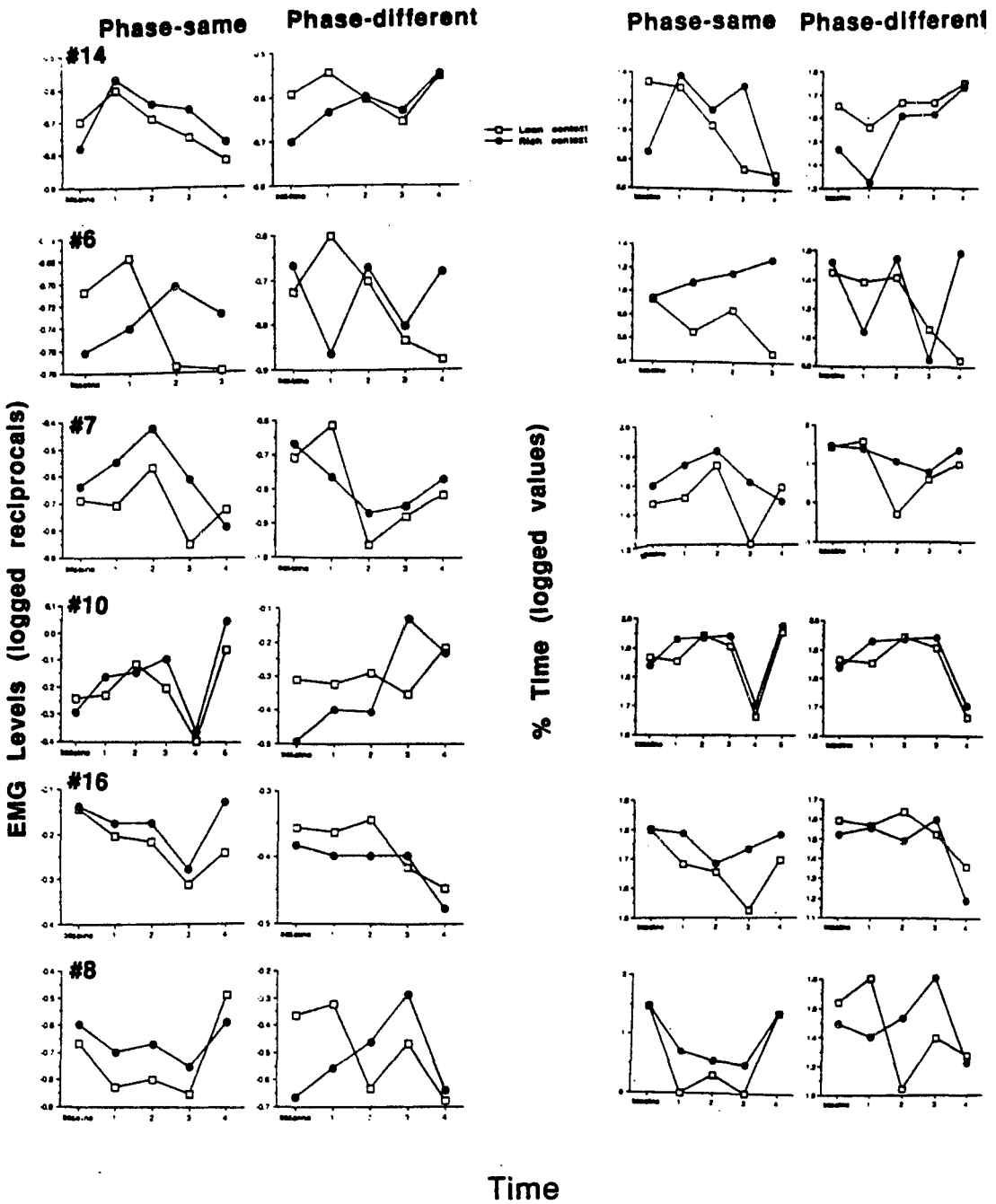
Subject	Phase-same	Phase-different
#6	.56	.03
#7	.09	-.09
#8	-.04	.96
#9	.25	.17
#10	.21	.22
#11	.26	- - -
#12	.11	.22
#13	.09	- - -
#14	.16	.22
#15	.09	.28
#16	.16	.01
#17	.09	.01
#1	- - -	-.08

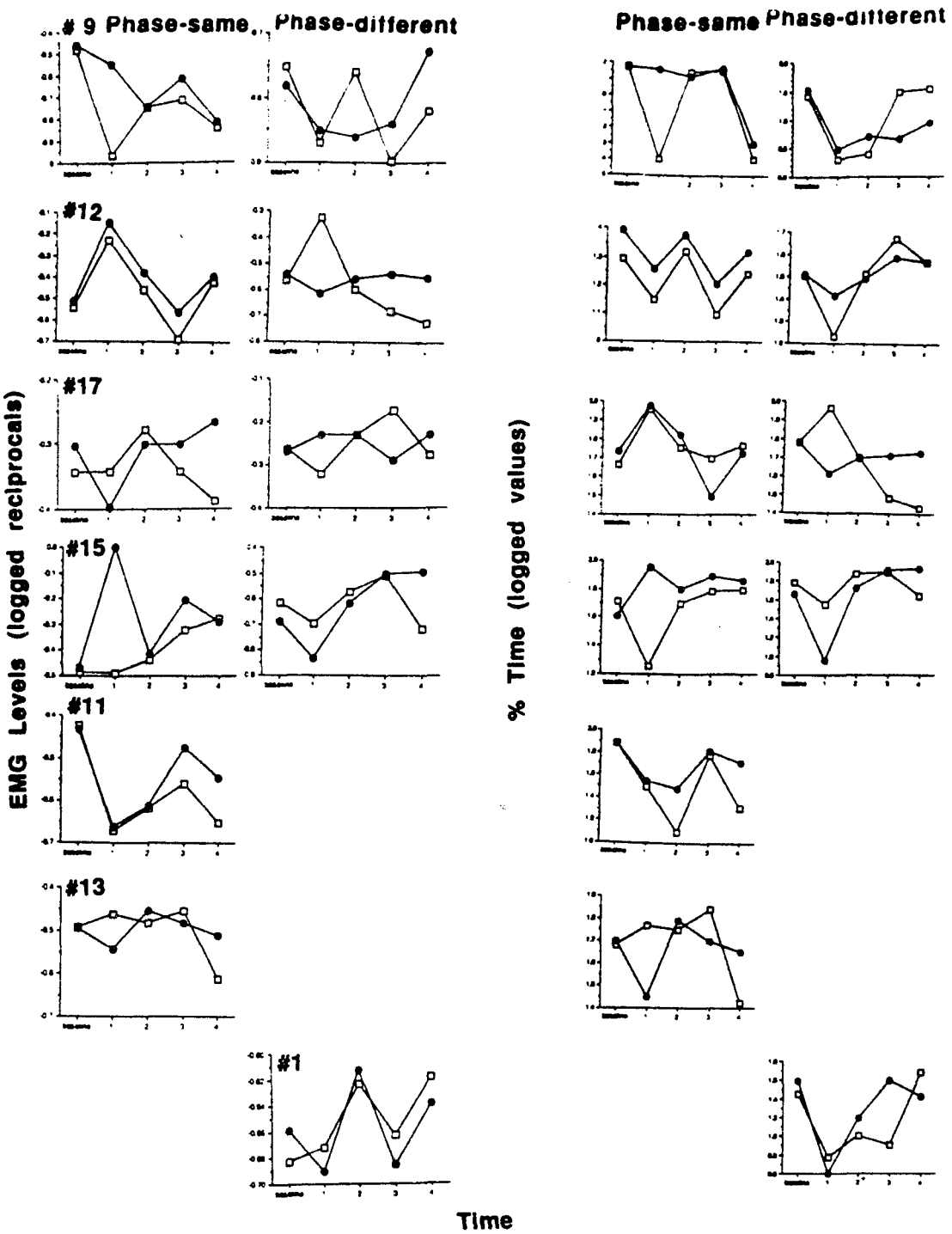
Table 4A P-difference values from the EMG data.

Subject	Phase-same	Phase-different
#6	.12	.09
#7	.01	.05
#8	.01	.40
#9	0	.13
#10	.25	.31
#11	.78	- - -
#12	-.22	.29
#13	-.06	- - -
#14	.35	.14
#15	.49	.53
#16	.32	.05
#17	-.02	-.04
#1	- - -	-.14

Table 4B P-difference values from the % time data.

APPENDIX E. INDIVIDUAL DATA FROM EXPERIMENT TWO




9 Phase-same
Phase-different
Phase-same
Phase-different
#12
#17
#15
#11
#13
#1
EMG Levels (logged reciprocals)
% Time (logged values)
Time